CHAPTER 2

PROB #2-1

1. $w_u = 1.4D = (1.4)(80) = 112$ psf

2. $w_u = 1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$
   $= (1.2)(80) + (1.6)(60) + (0.5)(20) = 202$ psf ←

3. $w_u = 1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (0.5L \text{ or } 0.8W)$
   $= (1.2)(80) + (1.6)(20) + (0.5)(60) = 158$ psf

4. $w_u = 1.2D + 1.6W + 0.5L + 0.5(L_r \text{ or } S \text{ or } R)$
   $= (1.2)(80) + (0.5)(60) + (0.5)(20) = 136$ psf

5. $w_u = 1.2D \pm 1.0E + 0.5L + 0.2S$
   $= (1.2)(80) + (0.5)(60) + (0.2)(20) = 130$ psf

6. $w_u = 0.9D \pm (1.6W \text{ or } 1.0E)$
   $= (0.9)(80) = 72$ psf

$\boxed{\text{Ans. } w_u = 202 \text{ psf}}$

vgcm^{c}

PROB#2-2

1. $w_u = 1.4D = (1.4)(50) = 70$ psf

2. $w_u = 1.2D + 1.6L + 0.5\,(L_r \text{ or } S \text{ or } R)$

   $= (1.2)(50) + (1.6)(70) = 172$ psf $\leftarrow$

3. $w_u = 1.2D + 1.6\,(L_r \text{ or } S \text{ or } R) + (0.5L \text{ or } 0.8W)$

   $= (1.2)(50) + (0.5)(70) = 95$ psf

4. $w_u = 1.2D + 1.6W + 0.5L + 0.5\,(L_r \text{ or } S \text{ or } R)$

   $= (1.2)(50) + (0.5)(70) = 95$ psf

5. $w_u = 1.2D \pm 1.0E + 0.5L + 0.2S$

   $= (1.2)(50) + (0.5)(70) = 95$ psf

6. $w_u = 0.9D \pm (1.6W \text{ or } 1.0E)$

   $= (0.9)(50) = 45$ psf

$\boxed{\text{Ans. } w_u = 172 \text{ psf}}$

✓ JCMc

PROB#2-3

1. $P_u = 1.4D = (1.4)(8000) = 11{,}200$ lbs

2. $P_u = 1.2D + 1.6L + 0.5\ (L_r \text{ or } S \text{ or } R)$
$= (1.2)(8000) + (1.6)(4000) + (0.5)(2000) = 17{,}000$ lbs $\leftarrow$

3. $P_u = 1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (0.5L \text{ or } 0.8W)$
$= (1.2)(8000) + (1.6)(2000) + (0.5)(4000) = 14{,}800$ lbs

4. $P_u = 1.2D + 1.6W + 0.5L + 0.5(L_r \text{ or } S \text{ or } R)$
$= (1.2)(8000) + (0.5)(4000) + (0.5)(2000) = 12{,}600$ lbs

5. $P_u = 1.2D \pm 1.0E + 0.5L + 0.2S$
$= (1.2)(8000) + (0.5)(4000) + (0.2)(900) = 11{,}780$ lbs

6. $P_u = 0.9D \pm (1.6W \text{ or } 1.0E)$
$= (0.9)(8000) = 7200$ lbs

$\boxed{\text{Ans. } P_u = 17{,}000 \text{ lbs}}$

✓ JCMc

PROB#2-4

1. $w_u = 1.4D = (1.4)(70) = 98$ psf

2. $w_u = 1.2D + 1.6L + 0.5\,(L_r \text{ or } S \text{ or } R)$
$= (1.2)(70) + (1.6)(40) + (0.5)(14) = 155$ psf

3. $w_u = 1.2D + 1.6\,(L_r \text{ or } S \text{ or } R) + (0.5L \text{ or } 0.8W)$
$= (1.2)(70) + (1.6)(14) + (0.5)(40) = 126.4$ psf

4. $w_u = 1.2D + 1.6W + 0.5L + 0.5\,(L_r \text{ or } S \text{ or } R)$
$= (1.2)(70) + (0.5)(40) + (0.5)(14) = 111$ psf

5. $w_u = 1.2D \pm 1.0E + 0.5L + 0.2S$
$= (1.2)(70) + (1.0)(80) + (0.5)(40) = 184$ psf ←
or
$= (1.2)(70) - (1.0)(80) + (0.5)(40) = 24$ psf

6. $w_u = 0.9D \pm (1.6W \text{ or } 1.0E)$
$= (0.9)(70) + (1.0)(80) = 143$ psf
or
$= (0.9)(70) - (1.0)(80) = -17$ psf ←

$\boxed{\text{Ans. } w_u = +184 \text{ psf and } -17 \text{ psf}}$

✓ JCMc

PROB # 2-5

1. $w_a = D = 80\text{ psf}$

2. $w_a = D + L = 80 + 60 = 140\text{ psf}$ ←

3. $w_a = D + (L_r \text{ or } S \text{ or } R) = 80 + 20 = 100\text{ psf}$

4. $w_a = D + 0.75L + 0.75\,(L_r \text{ or } S \text{ or } R)$
   $= 80 + (0.75)(60) + (0.75)(20) = 140\text{ psf}$ ←

5. $w_a = D + (W \text{ or } 0.7E)$
   $= 80\text{ psf}$

6. $w_a = D + 0.75(W \text{ or } 0.7E) + 0.75L + 0.75(L_r \text{ or } S \text{ or } R)$
   $= 80 + (0.75)(60) + (0.75)(20) = 140\text{ psf}$ ←

7. $w_a = 0.6D \pm (W \text{ or } 0.7E)$
   $= (0.6)(80) = 48\text{ psf}$

$\boxed{\text{Ans. } w_a = 140\text{ psf}}$

rgcm[c]

PROB # 2-6

1. $w_a = D = 50 \text{ psf}$

2. $w_a = D + L = 50 + 70 = 120 \text{ psf}$ ←

3. $w_a = D + (L_r \text{ or } S \text{ or } R) = 50 \text{ psf}$

4. $w_a = D + 0.75L + 0.75(L_r \text{ or } S \text{ or } R)$
   $= 50 + (0.75)(70) = 102.5 \text{ psf}$

5. $w_a = D \pm (W + 0.7E) = 50 \text{ psf}$

6. $w_a = D + 0.75(W \text{ or } 0.7E) + 0.75L + 0.75(L_r \text{ or } S \text{ or } R)$
   $= 50 + (0.75)(70) = 102.5 \text{ psf}$

7. $w_a = 0.6D \pm (W \text{ or } 0.7E)$
   $= (0.6)(50) = 30 \text{ psf}$

$\boxed{\text{Ans. } w_a = 120 \text{ psf}}$

✓ gcm^c

PROB # 2-7

1. $P_a = D = 8000$ lbs

2. $P_a = D + L = 8000 + 4000 = 12{,}000$ lbs

3. $P_a = D + (L_r \text{ or } S \text{ or } R)$

   $= 8000 + 2000 = 10{,}000$ lbs

4. $P_a = D + 0.75L + 0.75\,(L_r \text{ or } S \text{ or } R)$

   $= 8000 + (0.75)(4000) + (0.75)(2000) = 12{,}500$ lbs $\leftarrow$

5. $P_a = D \pm (W \text{ or } 0.7E) = 8000$ lbs

6. $P_a = D + 0.75(W \text{ or } 0.7E) + 0.75L + 0.75\,(L_r \text{ or } S \text{ or } R)$

   $= 8000 + (0.75)(4000) + (0.75)(2000) = 12{,}500$ lbs $\leftarrow$

7. $P_a = 0.6D \pm (W \text{ or } 0.7E) = (0.6)(8000) = 4800$ lbs

$$\boxed{\text{Ans. } P_a = 12{,}500 \text{ lbs}}$$

rjc m^c

PROB # 2 – 8

1. $w_a = D = 70 \text{ psf}$

2. $w_a = D + L = 70 + 40 = 110 \text{ psf}$

3. $w_a = D + (L_r \text{ or } S \text{ or } R) = 70 + 14 = 84 \text{ psf}$

4. $w_a = D + 0.75L + 0.75(L_r \text{ or } S \text{ or } R)$
   $= 70 + (0.75)(40) + (0.75)(14) = 110.5 \text{ psf}$

5. $w_a = D \pm (W \text{ or } 0.7E)$
   $= 70 + (0.7)(80) = 126 \text{ psf}$
   or
   $= 70 - (0.7)(80) = 14 \text{ psf}$

6. $w_a = D + 0.75(W \text{ or } 0.7E) + 0.75L + 0.75(L_r \text{ or } S \text{ or } R)$
   $= 70 + (0.75)(0.7)(80) + (0.75)(40) + (0.75)(14)$
   $= 152.5 \text{ psf} \leftarrow$

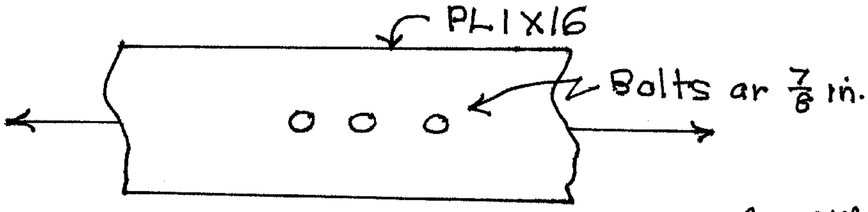
7. $w_a = 0.6D \pm (W \text{ or } 0.7E)$
   $= (0.6)(70) + (0.7)(80) = 98 \text{ psf}$
   or
   $= (0.6)(70) - (0.7)(80) = -14 \text{ psf}$

$\boxed{\text{Ans. } w_a = 98 \text{ psf or } -14 \text{ psf}}$

✓ JCM^c

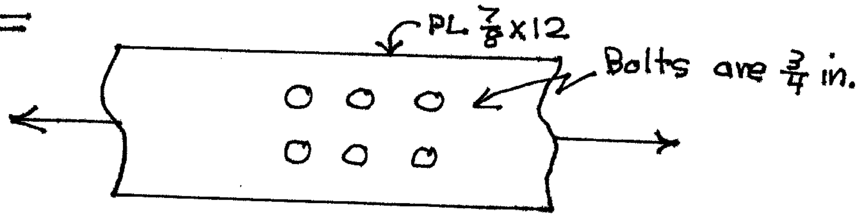
CHAPTER 3

PROB # 3-1



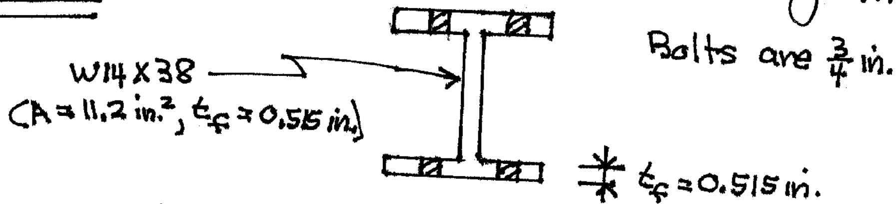
$$\text{Net } A = (1)(16) - (1)\left(\tfrac{7}{8}+\tfrac{1}{8}\right)(1) = \boxed{15 \text{ in.}^2}$$

PROB # 3-2



$$\text{Net } A = \left(\tfrac{7}{8}\right)(12) - (2)\left(\tfrac{3}{4}+\tfrac{1}{8}\right)\left(\tfrac{7}{8}\right) = \boxed{8.97 \text{ in.}^2}$$

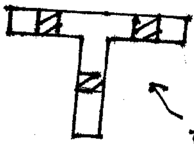
PROB # 3-3



$$\text{Net } A = 11.2 - (4)\left(\tfrac{3}{4}+\tfrac{1}{8}\right)(0.515) = \boxed{9.40 \text{ in.}^2}$$

PROB #3-4

WT 10.5 x 61
($A = 17.9 \text{ in.}^2$, $t_w = 0.600$ in, $t_f = 0.960$ in.)



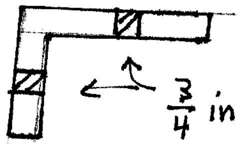
$$\text{Net } A = 17.9 - (2)\left(\tfrac{7}{8}+\tfrac{1}{8}\right)(0.960) - (1)\left(\tfrac{7}{8}+\tfrac{1}{8}\right)(0.600)$$
$$= \boxed{15.38 \text{ in.}^2}$$

✓ JCM

PROB #3-5

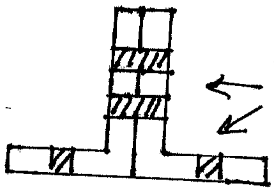
Using 1 L8x4x$\frac{3}{4}$ ($A = 8.44 \text{ in.}^2$)

$$\text{Net } A = 8.44 - (2)\left(\tfrac{3}{4}+\tfrac{1}{8}\right)\left(\tfrac{3}{4}\right)$$
$$= \boxed{7.13 \text{ in.}^2}$$



✓ JCM

PROB #3-6



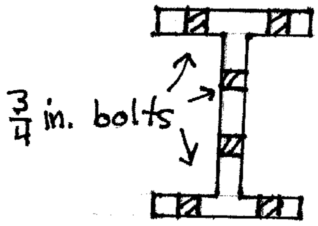
Using 2Ls 7x4x$\frac{5}{8}$ ($A = 13.0 \text{ in.}^2$)

$$\text{Net } A = 13.0 - (2)\left(\tfrac{7}{8}+\tfrac{1}{8}\right)\left(\tfrac{5}{8}\right) - (2)\left(\tfrac{7}{8}+\tfrac{1}{8}\right)\left(2 \times \tfrac{5}{8}\right)$$
$$= \boxed{9.25 \text{ in.}^2}$$

✓ JCM

Note: Areas for single angles times two vary a little from the double angle areas given in Steel Manual

PROB #3-7

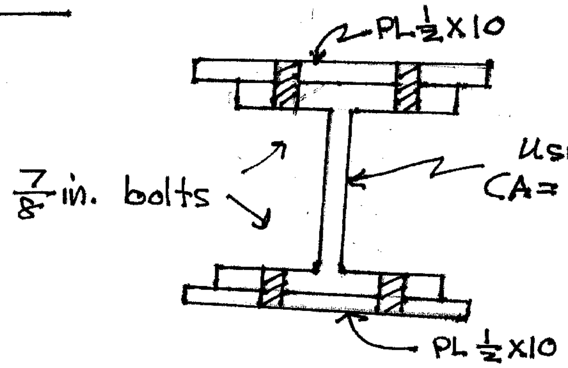


Using a W21X44
(A = 13.0 in.^{2}, t_w = 0.350 in., t_f = 0.450 in.)

$$\text{Net } A = 13.0 - (4)\left(\tfrac{3}{4}+\tfrac{1}{8}\right)(0.450) - (2)\left(\tfrac{3}{4}+\tfrac{1}{8}\right)(0.350)$$
$$= \boxed{10.81 \text{ in.}^2}$$

✓ gcm^c

PROB #3-8



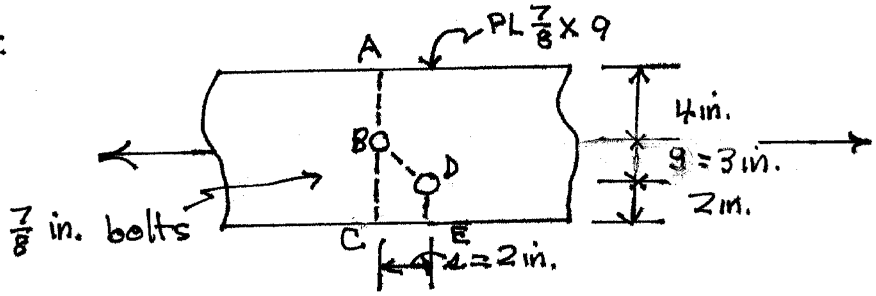
Using a W21X57
(A = 16.7 in.^{2}, t_f = 0.650 in.)

$$A_g = 16.7 + (2)\left(\tfrac{1}{2}\times 10\right) = 26.7 \text{ in.}^2$$

$$\text{Net } A = 26.7 - (4)\left(\tfrac{7}{8}+\tfrac{1}{8}\right)(0.650 + 0.500)$$
$$= \boxed{22.1 \text{ in.}^2}$$

✓ gcm^c

PROB # 3-9



Net widths

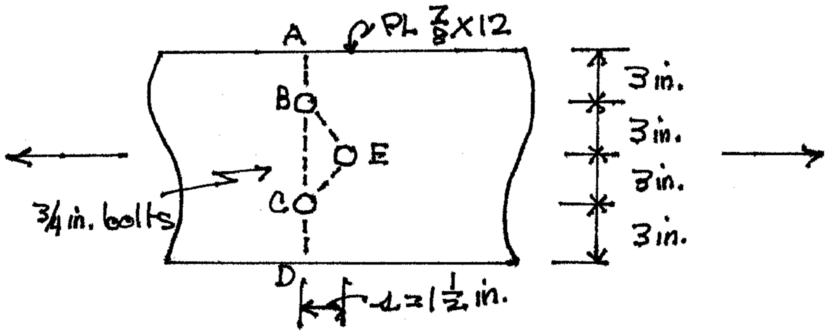
ABC = $9-(1)(\frac{7}{8}+\frac{1}{8}) = 8.00$ in.

ABDE = $9-(2)(\frac{7}{8}+\frac{1}{8}) + \frac{(2)^2}{(4)(3)} = 7.33$ in. ←

Net Area = $(7.33)(\frac{7}{8}) = \boxed{6.41 \text{ in.}^2}$

vgcmc

PROB # 3-10



Net widths

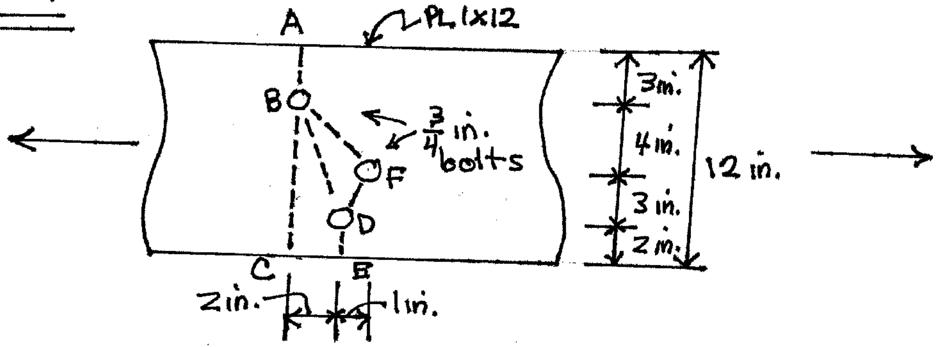
ABCD $= 12-(2)(\frac{3}{4}+\frac{1}{8}) = 10.25$ in.

ABECD $= 12-(3)(\frac{3}{4}+\frac{1}{8}) + (2)(\frac{1.5^2}{4\times 3}) = 9.75$ in. ←

Net Area $= (9.75)(0.875) = \boxed{8.53 \text{ in.}^2}$

vgcmc

PROB #3-11



Net widths

$ABC = 12 - (1)(\frac{3}{4} + \frac{1}{8}) = 11.125$ in.

$ABDE = 12 - (2)(\frac{3}{4} + \frac{1}{8}) + \frac{(2)^2}{(4)(7)} = 10.39$ in.

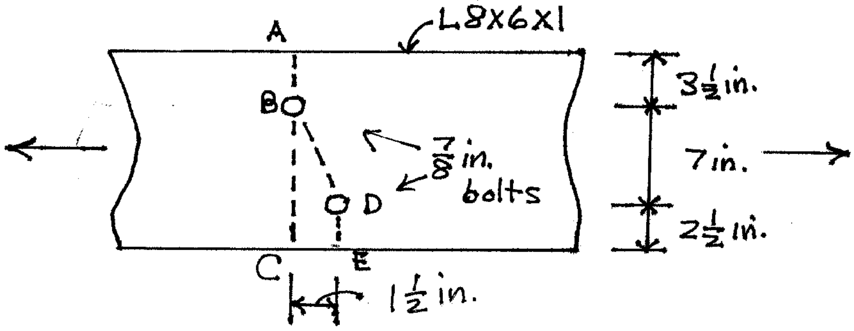
$ABFDE = 12 - (3)(\frac{3}{4} + \frac{1}{8}) + \frac{(3)^2}{(4)(4)} + \frac{(1)^2}{(4)(3)} = 10.02$ in. ←

Net Area = $(10.02)(1.0) = \boxed{10.02 \text{ in.}^2}$

√gcm©

PROB #3-12

Flattening angle



Net widths

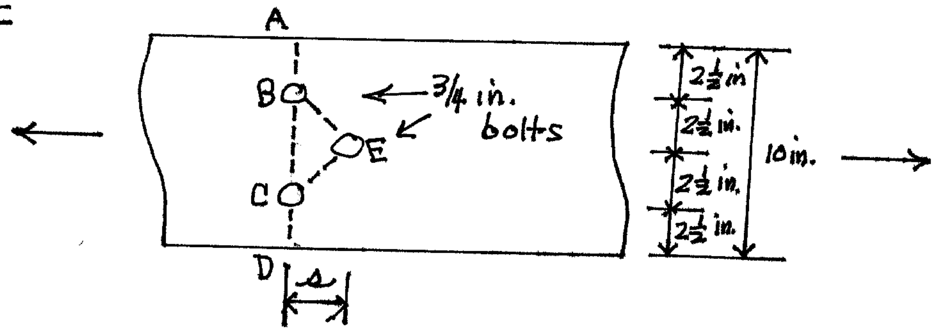
$ABC = 13.00 - (1)(\frac{7}{8} + \frac{1}{8}) = 12.00$ in.

$ABDE = 13.00 - (2)(\frac{7}{8} + \frac{1}{8}) + \frac{(1.5)^2}{(4)(7)} = 11.08$ in. ←

Net Area = $(11.08)(1) = \boxed{11.08 \text{ in.}^2}$

√gcm©

PROB # 3-13



Net widths

$$ABCD = 10 - (2)\left(\frac{3}{4}+\frac{1}{8}\right) = 8.25 \text{ in.}$$

$$ABECD = 10 - (3)\left(\frac{3}{4}+\frac{1}{8}\right) + (2)\frac{s^2}{(4)(2.5)} = 7.375 + \frac{s^2}{5}$$

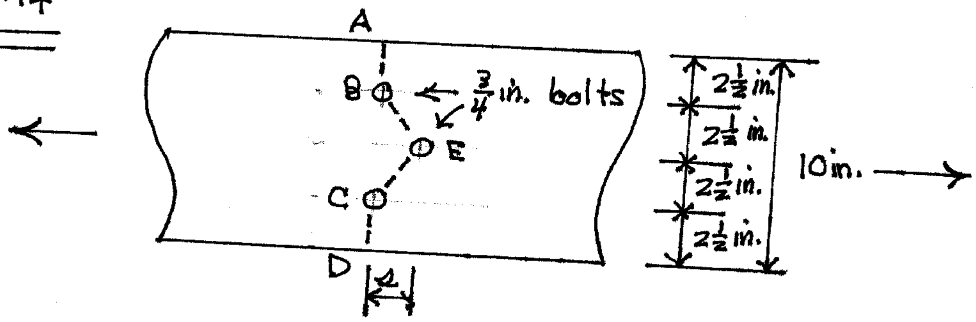
Equating

$$8.25 = 7.375 + \frac{s^2}{5}$$

$$\boxed{s = 2.09 \text{ in.}}$$

✓ JCMc

PROB # 3-14



Net width with $2\frac{1}{2}$ bolt holes subtracted

$$= 10.00 - \left(2\tfrac{1}{2}\right)\left(\frac{3}{4}+\frac{1}{8}\right) = 7.8125$$

Net width ABECD

$$= 10.00 - (3)\left(\frac{3}{4}+\frac{1}{8}\right) + (2)\frac{s^2}{(4)(2.5)} = 7.375 + \frac{s^2}{5}$$

Equating

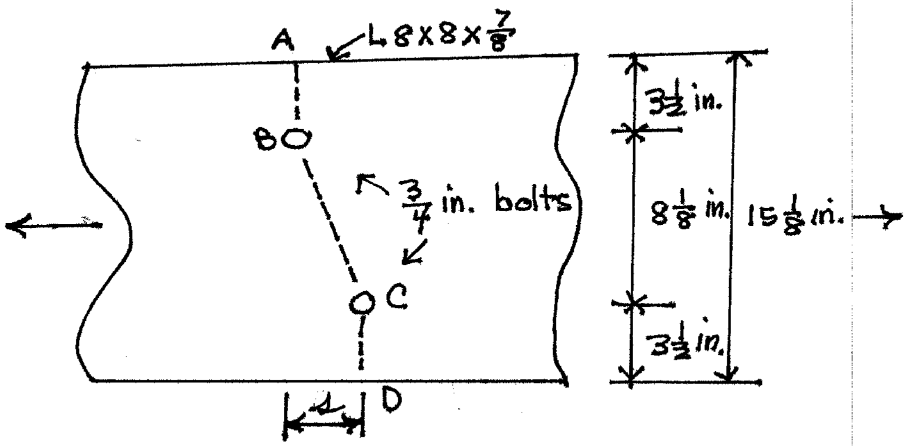
$$7.8125 = 7.375 + \frac{s^2}{5}$$

$$\boxed{s = 1.48 \text{ in.}}$$

✓ JCMc

PROB # 3-15

Flattening the angle



(a) Net width with 1 hole subtracted

$= 15.125 - (1)\left(\frac{3}{4}+\frac{1}{8}\right) = 14.25$ in.

Net width ABCD

$= 15.125 - (2)\left(\frac{3}{4}+\frac{1}{8}\right) + \frac{s^2}{(4)(8.125)}$

$= 13.375 + \frac{s^2}{32.5}$

Equating

$14.25 = 13.375 + \frac{s^2}{32.5}$

$\boxed{s = 5.33 \text{ in.}}$

(b) Net A if $s = 2$ in.

Net width ABCD $= 15.125 - (2)\left(\frac{3}{4}+\frac{1}{8}\right) + \frac{(2)^2}{(4)(8.125)}$

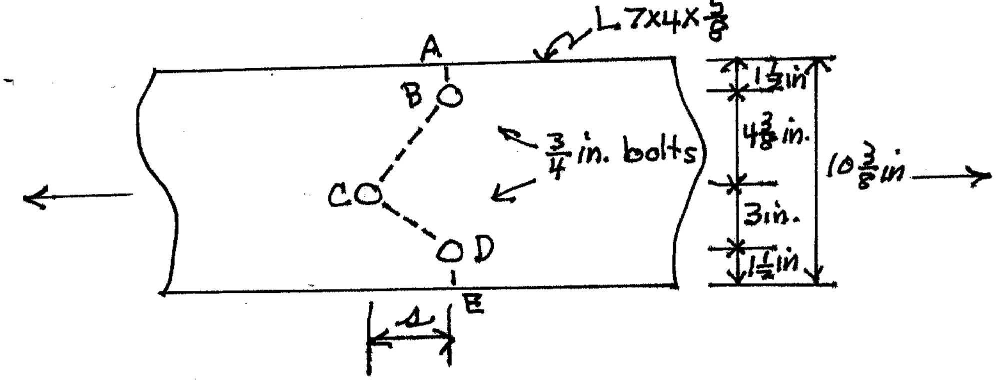
$= 13.50$ in.

Net area $= (13.50)\left(\frac{7}{8}\right) = \boxed{11.81 \text{ in.}^2}$

rjcmc

PROB # 3-16

Flattening the angle



Net width ABCDE

$$= 10.375 - (3)\left(\frac{3}{4}+\frac{1}{8}\right) + \frac{s^2}{(4)(4.375)} + \frac{s^2}{(4)(3)}$$

$$= 7.75 + 0.1405\, s^2$$

Net width with 2 holes out

$$= 10.375 - (2)\left(\frac{3}{4}+\frac{1}{8}\right) = 8.625 \text{ in.}$$

Equating

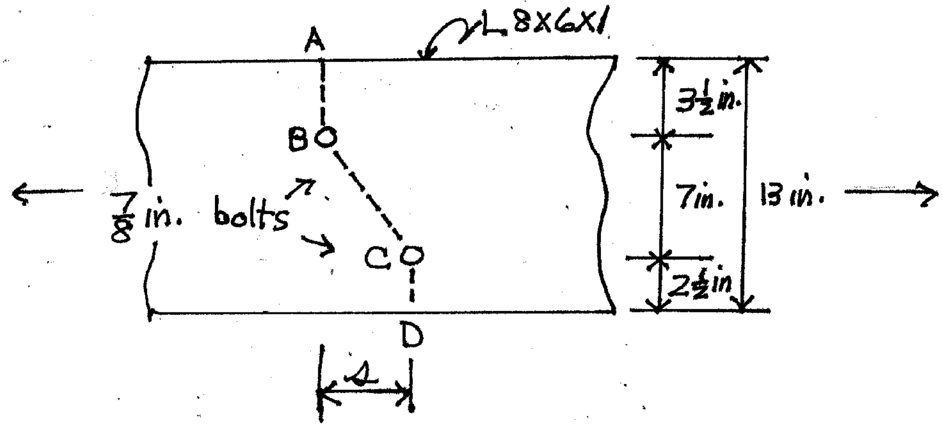
$$7.75 + 0.1405 s^2 = 8.625$$

$$\boxed{s = 2.50 \text{ in.}}$$

✓ JCMc

PROB # 3.17

Flattening the angle



Net width with 1 hole out

$$= 13 - (1.5)\left(\frac{7}{8} + \frac{1}{8}\right) = 11.50 \text{ in.}$$

Net width ABCD

$$= 13.00 - (2)\left(\frac{7}{8} + \frac{1}{8}\right) + \frac{s^2}{(4)(7)}$$

$$= 11.00 + \frac{s^2}{28}$$

Equating

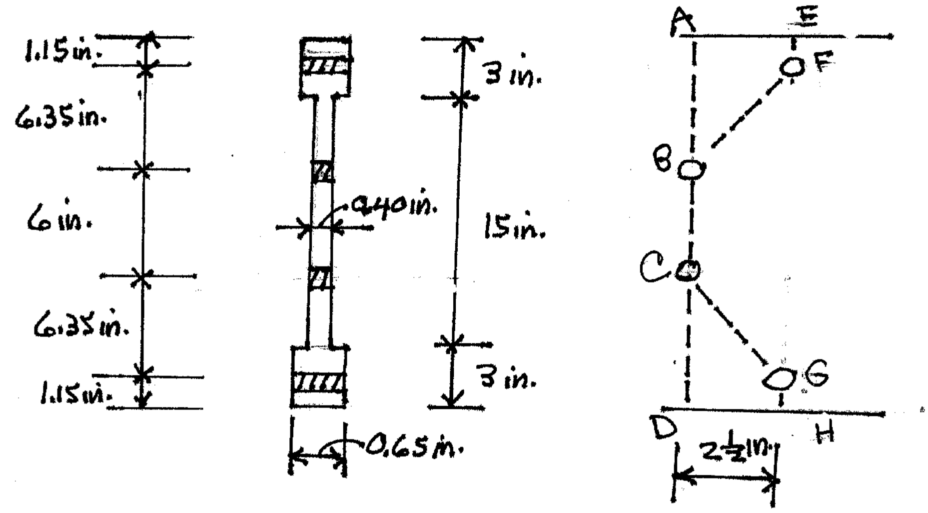
$$11.50 = 11.00 + \frac{s^2}{28}$$

$$\boxed{s = 3.74 \text{ in.}}$$

vgcm©

PROB #3-18

Using a C15x33.9 ($A = 10.0\ in.^2$, $t_w = 0.400\ in.$, $t_f = 0.650\ in.$)



Net areas

$$ABCD = 10.00 - (2)\left(\frac{3}{4}+\frac{1}{8}\right)(0.40) = 9.30\ in.^2$$

$$EFBCGH = 10.00 - (2)\left(\frac{3}{4}+\frac{1}{8}\right)(0.65) - (2)\left(\frac{3}{4}+\frac{1}{8}\right)(0.40) + (2)\frac{(2.5)^2}{(4)(6.35)}\left(\frac{0.65+0.40}{2}\right) = 8.42\ in.^2 \leftarrow$$

Noting that $U = 1.0$ since all parts are connected

$$A_e = UA_{net} = (1.0)(8.42) = \boxed{8.42\ in.^2}$$

JCMc

PROB # 3-19

Using 2 MCs 18x42.7 (For each $A = 12.60\text{ in}^2$, $t_f = 0.625$ in.)
plus $2 - \frac{3}{4} \times 16$ PLs

$$A_{net} = (2)(12.60) + (2)(\tfrac{3}{4} \times 16) - (4)(\tfrac{7}{8} + \tfrac{1}{8})(0.625 + \tfrac{3}{4})$$

$$= 43.7\text{ in}^2$$

U given $= 0.85$

$$A_e = U A_{net} = (0.85)(43.7) = \boxed{37.14\text{ in.}^2}$$

✓ gcm^c

PROB # 3-20

Using 1 L 8x4x$\frac{3}{4}$ ($A = 8.44\text{ in.}^2$

$$A_{net} = 8.44 - (1)(1 + \tfrac{1}{8})(\tfrac{3}{4}) = 7.60\text{ in.}$$

$U = 0.60$ as given in AISC Table D3-1 (Case 8)

or

$$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{0.949}{2 \times 4} = \underline{\underline{0.88}} \leftarrow$$

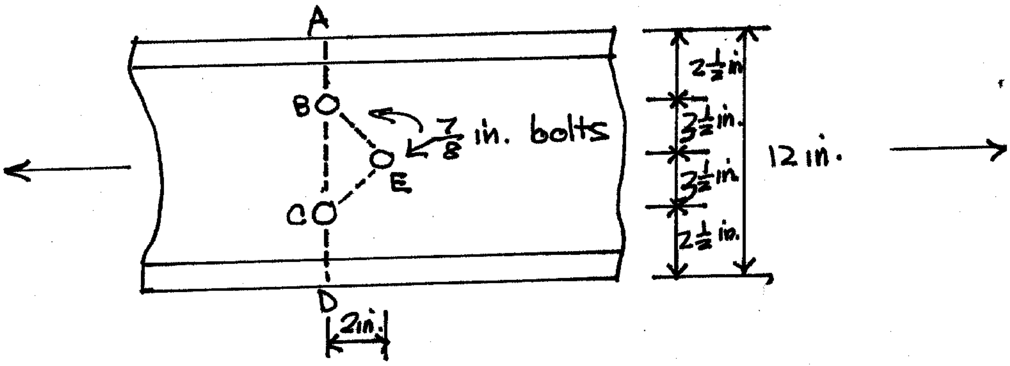
$$A_e = U A_n = (0.88)(7.60) = \boxed{6.69\text{ in.}}$$

✓ gcm^c

19

PROB # 3-21

Using an MC12X40 ($A_g = 11.8\text{ in.}^2$, $t_w = 0.590$ in., $\bar{x} = 1.04$ in.)



Net areas

$$ABCD = 11.8 - (2)\left(\tfrac{7}{8}+\tfrac{1}{8}\right)(0.590) = 10.62\text{ in.}^2$$

$$ABECD = 11.8 - (3)\left(\tfrac{7}{8}+\tfrac{1}{8}\right)(0.590) + (2)\frac{(2)^2}{(4)(3.5)}(0.590)$$

$$= 10.37\text{ in.}^2 \leftarrow$$

$$u = 1 - \frac{\bar{x}}{L} = 1 - \frac{1.04}{2 \times 4} = 0.87$$

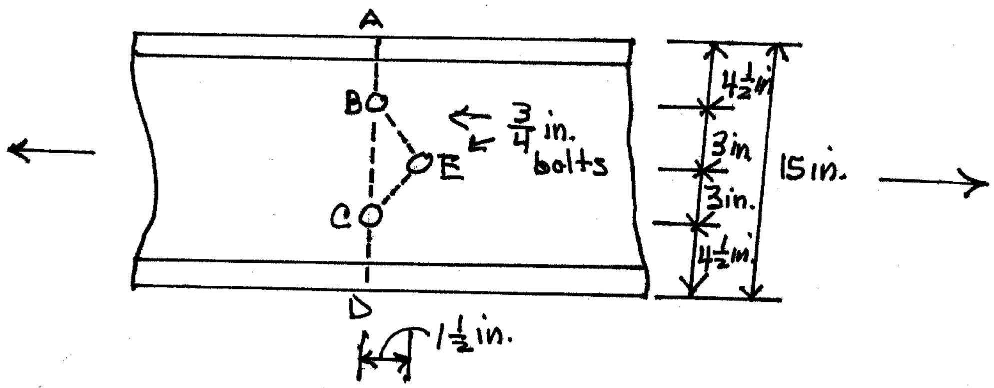
Effective area

$$A_e = u A_n = (0.87)(10.37) = \boxed{9.02\text{ in.}^2}$$

vgcm

PROB # 3-22

Using a C15X40 ($A = 11.8\ in.^2$, $t_w = 0.520\ in.$, $\bar{x} = 0.778\ in.$)



Net areas

$$ABCD = 11.8 - (2)\left(\tfrac{3}{4}+\tfrac{1}{8}\right)(0.520) = 10.89\ in.^2$$

$$ABECD = 11.8 - (3)\left(\tfrac{3}{4}+\tfrac{1}{8}\right)(0.520) + (2)\frac{(1.5)^2}{(4)(3)}(0.520)$$

$$= 10.63\ in.^2 \leftarrow$$

Effective area

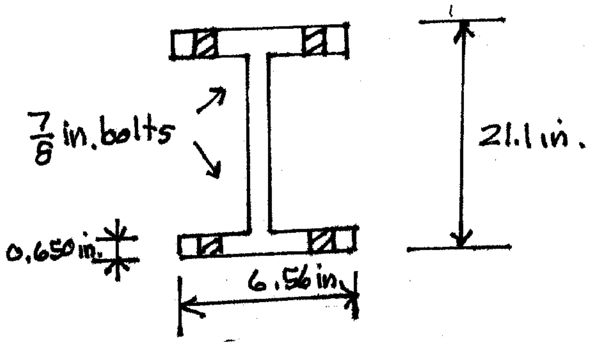
$$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{0.778}{9} = 0.914$$

$$A_e = U A_n = (0.914)(10.63)$$

$$= \boxed{9.72\ in.^2}$$

✓ JCMc

PROB # 3-23



Using a W21X57 ($A_g = 16.7 \text{ in.}^2$, $\bar{y} = 2.85 \text{ in.}$)

$A_{net} = 16.7 - (4)(\frac{7}{8} + \frac{1}{8})(0.650) = 14.1 \text{ in.}^2$

$\bar{y} = \bar{x}$ for WT10.5 x 28.5 = 2.85 in.

$u = 1 - \frac{2.85}{3 \times 4} = 0.762$

or

$u = 0.85$ since $b_f = 6.56 < \frac{2}{3} \times 21.1 = 14.07$ in.

(AISC Table D3.1 Case 7)

$A_e = u A_n = (0.85)(14.1) = \boxed{11.98 \text{ in.}^2}$

✓ gcmc

PROB #3-24

Using 1L7x4x$\frac{3}{8}$ ($A = 3.98 \text{ in.}^2$, $\bar{x} = 0.861$ in.

Gross section yielding

$P_n = (36)(3.98) = 143.28$ k

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(143.28) = 129$ k	$\frac{P_n}{\Omega_t} = \frac{143.28}{1.67} = 85.8$ k

Tensile rupture strength

$A_n = 3.98 - (1)\left(\frac{3}{4} + \frac{1}{8}\right)\left(\frac{3}{8}\right) = 3.65 \text{ in.}^2$

$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{0.861}{8} = 0.892 \leftarrow$

or 0.6 Case 8 AISC Table D3.1

$A_e = (0.892)(3.65) = 3.26 \text{ in.}^2$

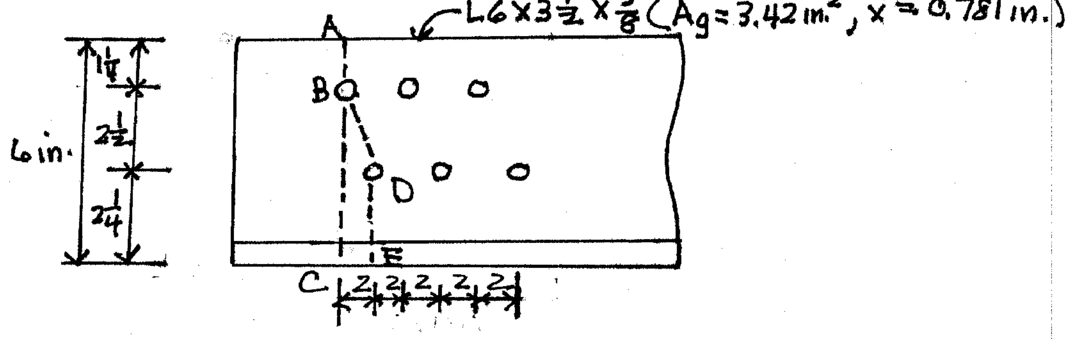
$P_n = (58)(3.26) = 189.1$ k

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(189.1) = 141.8$ k	$\frac{P_n}{\Omega_t} = \frac{189.1}{2.00} = 94.5$ k

ANSWRS $\boxed{\text{LRFD } 129 \text{ k}}$ $\boxed{\text{ASD } 85.8 \text{ k}}$

✓ JCMc

PROB # 3-25



Net areas

$$ABC = 3.42 - (1)\left(\tfrac{3}{4}+\tfrac{1}{8}\right)\left(\tfrac{3}{8}\right) = 3.09 \text{ in.}^2$$

$$ABDE = 3.42 - (2)\left(\tfrac{3}{4}+\tfrac{1}{8}\right)\left(\tfrac{3}{8}\right) + \frac{(2)^2}{(4)(2.5)}\left(\tfrac{3}{8}\right) = 2.914 \text{ in.}^2 \leftarrow$$

Effective area

$$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{0.781}{(2)(4)} = 0.90 \leftarrow$$

or $U = 0.60$ (Case 8 AISC Table D3.1)

$$A_e = U A_n = (0.90)(2.914) = 2.62 \text{ in.}^2$$

Gross section yielding

$$P_n = F_y A_g = (36)(3.42) = 123.1 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD with $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(123.1) = 110.8 \text{ k}$	$P_n/\Omega_t = \frac{123.1}{1.67} = 73.7 \text{ k}$ ←

Tensile rupture strength

$$P_n = F_u A_e = (58)(2.62) = 152.0 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(262) = 114 \text{ k}$	$P_n/\Omega_t = 152/2.00 = 76 \text{ k}$

ANS $\boxed{\text{LRFD} = 110.8 \text{ k}}$ $\boxed{\text{ASD} = 73.7 \text{ k}}$

✓ JCMc

PROB# 3-26

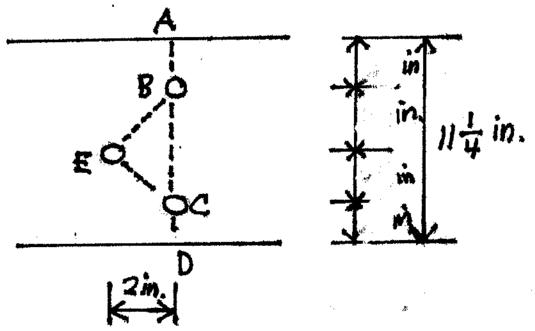
Using 2 Ls $6 \times 6 \times \frac{3}{4}$ ($A_g = 8.46$ in.^{2} each)

Gross section yielding

$$P_n = F_y A_g = (36)(8.46)(2) = 609.1$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(609.1) = 548.2k$	$\frac{P_n}{\Omega_t} = 609.1/1.67 = 364.7k$

Net widths



$$ABCD = 11.25 - (2)\left(\tfrac{7}{8} + \tfrac{1}{8}\right) = 9.25 \text{ in.}$$

$$ABECD = 11.25 - (3)\left(\tfrac{7}{8} + \tfrac{1}{8}\right) + \frac{(2)^2}{(4)(2.5)} + \frac{2^2}{(4)(5)} = 8.85 \text{ in.}$$

$$A_{net} = (8.85)\left(\tfrac{3}{4}\right) = 6.64 \text{ in.}^2$$

Effective area

$U = 1.0$ since both angle legs connected

$$A_e = UA_n = (1.0)(6.64)(2) = 13.28 \text{ in.}^2$$

Tensile rupture strength

$$P_n = F_u A_e = (58)(13.28) = 770.2k$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(770.2) = 577.6k$	$\frac{P_n}{\Omega_t} = \frac{770.2}{2.00} = 385.1k$

Ans → $\boxed{\text{LRFD} = 548.2k}$ $\boxed{\text{ASD} = 364.7k}$

PROB # 3-27

Using a W12X53 ($A_g = 15.6 in.^2$, $d = 12.1 in.$, $b_f = 10.00 in.$, $t_f = 0.575 in.$)

Nominal or available tensile strength of member

$$P_n = F_y A_g = (50)(15.6) = 780 k$$

(a) Gross section yielding

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(780) = 702 k$	$\frac{P_n}{\Omega_t} = \frac{780}{1.67} = 467.1 k$

(b) Tensile rupture strength

$A_n = 15.6 - (4)(\frac{7}{8} + \frac{1}{8})(0.575) = 13.3 in.^2$

$\bar{x} = 1.02$ for one half of a W12X53 (WT6X26.5)

$U = 1 - \frac{1.02}{6} = 0.83$

$b_f = 10.00 in > (\frac{2}{3})(12.1) = 8.07 in.$

$\therefore U = 0.90$ Case 7 AISC Table D3.1

$A_e = U A_n = (0.90)(13.3) = 11.97 in.^2$

$P_n = F_u A_e = (65)(11.97) = 778 k$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(778) = 583.5 k$	$\frac{P_n}{\Omega_t} = \frac{778}{2.00} = 389 k$

Ans. LRFD = $\boxed{583.5 k}$ ASD = $\boxed{389 k}$

✓ JCM$^{\underline{c}}$

PROB # 3-28

Using a W18x119 ($A_g = 35.1 \text{ in.}^2$, $b_f = 11.3 \text{ in.}$, $t_f = 1.06 \text{ in.}$, $d = 19.00 \text{ in.}$)

Nominal or available tensile strength of member

$$P_n = F_y A_g = (50)(35.1) = 1755 \text{ k}$$

(a) Gross section yielding

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(1755) = 1579.5 \text{ k}$	$\frac{P_n}{\Omega_t} = \frac{1755}{1.67} = 1050.9 \text{ k}$

(b) Tensile rupture strength

$$A_n = 35.1 - (4)(1 + \tfrac{1}{8})(1.06) = 30.33 \text{ in.}^2$$

$\bar{y} = 2.03$ for one half of a W18x119 (WT 9x59.5) $= \bar{x}$

$$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{2.03}{9.00} = 0.774$$

$$b_f = 11.3 < \left(\tfrac{2}{3}\right)(19.00) = 12.67 \text{ in.}$$

$\therefore U = 0.85$ Case 7 AISC Table D3.1

$$A_e = UA_n = (0.85)(30.33) = 25.78 \text{ in.}^2$$

$$P_n = F_u A_e = (65)(25.78) = 1675.7 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(1675.7) = 1257 \text{ k}$	$\frac{P_n}{\Omega_t} = \frac{1675.7}{2.00} = 837.8 \text{ k}$

Ans. LRFD $= \boxed{1257 \text{ k}}$ ASD $= \boxed{837.8 \text{ k}}$

rjcmc

PROB #3-29

Using a W18×119 ($A_g = 35.1\ in.^2$, $b_f = 11.3\ in.$, $t_f = 1.06\ in.$, $d = 19.00\ in.$)

Nominal available tensile strength of member

$$P_n = F_y A_g = (50)(35.1) = 1755\ k$$

(a) Gross section yielding

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(1755) = 1579.5\ k$	$\frac{P_n}{\Omega_t} = \frac{1755}{1.67} = 1050.9\ k$

(b) Tensile rupture strength

$A_n = 35.1 - (4)(1.06)(\frac{3}{4} + \frac{1}{8}) = 31.39\ in.^2$

$\bar{y} = \bar{x} = 2.03\ in.$ for one half of a W18×119 (WT9×59.5)

$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{2.03}{9} = 0.774$

$b_f = 11.3 < (\frac{2}{3})(19.00) = 12.67\ in.$

$\therefore U = 0.85$ Case 7 AISC Table D3.1

$A_e = U A_n = (0.85)(31.39) = 26.68\ in.^2$

$P_n = F_u A_e = (70)(26.68) = 1867.6\ k$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(1867.6) = 1400.7\ k$	$\frac{P_n}{\Omega_t} = \frac{1867.6}{2.00} = 933.8\ k$

Ans. LRFD = $\boxed{1400.7\ k}$ ASD = $\boxed{933.8\ k}$

JCMc

PROB # 3-30

Using a W14X61 ($A_g = 17.9$ in.^{2}, $d = 13.9$ in., $b_f = 10.0$ in., $t_f = 0.645$ in.)

Nominal or available tensile strength of member

$$P_n = F_y A_g = (50)(17.9) = 895k$$

(a) Gross section yielding

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(895) = 805.5k$	$\frac{P_n}{\Omega_t} = \frac{895}{1.67} = 535.9\,k$

(b) Tensile rupture strength

$A_n = 17.9 - (4)(\frac{3}{4} + \frac{1}{8})(0.645) = 15.64$ in.^{2}

$\bar{x} = \bar{y} = 1.25$ in. for half of a W14X61 (WT 7X30.5)

$U = 1 - \frac{1.25}{8} = 0.843$

$b_f = 10.00 > (\frac{2}{3})(13.9) = 9.27$ in.

$\therefore U = 0.90$ Case 7 AISC Table D3.1

$A_e = U A_n = (0.90)(15.64) = 14.08$ in.^{2}

$P_n = F_u A_e = (65)(14.08) = 915.2k$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(915.2) = 686.4k$	$\frac{P_n}{\Omega_t} = \frac{915.2}{2.00} = 457.6k$

Ans. LRFD = $\boxed{686.4k}$ ASD = $\boxed{457.6k}$

✓ JCMc

PROB# 3-31

Using a C12X30 ($A_g = 8.81 in^2$, $d = 12.0$ in., $t_w = 0.510$ in., $\bar{x} = 0.674$ in.)

Nominal or available tensile strength of member

(a) Gross section yielding

$$P_n = F_y A_g = (50)(8.81) = 440.5k$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(440.5) = 396.4k$	$\frac{P_n}{\Omega_t} = \frac{440.5}{1.67} = 263.8k$

(b) Tensile rupture strength

$$A_n = 8.81 - (3)(\tfrac{7}{8} + \tfrac{1}{8})(0.510) = 7.28 in.$$

$$\bar{x} = \bar{y} = 0.674 \text{ in.}$$

$$L = (3)(3) = 9 \text{ in.}$$

$$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{0.674}{9} = 0.925$$

$$A_e = U A_n = (0.925)(7.28) = 6.734 \text{ in.}^2$$

$$P_n = F_u A_e = (65)(6.734) = 437.7k$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(437.7) = 328.3k$	$\frac{P_n}{\Omega_t} = \frac{437.7}{2.00} = 218.8k$

Ans. LRFD $\boxed{328.3k}$ ASD = $\boxed{218.8k}$

rgcm^c

PROB# 3-32

Using a WT15x74 with transverse welds to its flange only ($A_g = 21.7\ in.^2$, $t_f = 1.18\ in.$, $\bar{y} = 3.84\ in.$)

Nominal or available tensile strength of member

(a) Gross section yielding

$P_n = F_y A_g = (50)(21.7) = 1085\ k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(1085) = 976.5\ k$	$\frac{P_n}{\Omega_t} = \frac{1085}{1.67} = 649.7\ k$

(b) Tensile rupture strength

A_n = area of flange $= b_f t_f = (10.5)(1.18) = 12.39\ in.^2$

$U = 1.0$

$A_e = U A_n = (1.0)(12.39) = 12.39\ in.^2$

$P_n = F_u A_e = (65)(12.39) = 805.3\ k$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(805.3) = 604\ k$	$\frac{P_n}{\Omega_t} = \frac{805.3}{2.00} = 402.6\ k$

Ans. $\boxed{LRFD = 604\ k}$ $\boxed{ASD = 402.6\ k}$

✓ JCMᶜ

PROB# 3-33

Using two MCs 18X42.7 (A_g = 12.6 in.^{2} each, d = 18.0 in., t_w = 0.450 in.

(a) Gross section yielding

$P_n = F_y A_g = (36)(12.6)(2) = 907.2\,k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(907.2) = 816.5\,k$	$\frac{P_n}{\Omega_t} = \frac{907.2}{1.67} = 543.2\,k$

(b) Tensile rupture strength

A_n = web area $= (2)(18.0)(0.450) = 16.2$ in.^{2}

$U = 1.0$

$A_e = U A_n = (1.0)(16.2) = 16.2$ in.^{2}

$P_n = F_u A_e = (58)(16.2) = 939.6\,k$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(939.6) = 704.7\,k$	$\frac{P_n}{\Omega_t} = \frac{939.6}{2.00} = 469.8\,k$

Answrs $\boxed{\text{LRFD } 704.7\,k}$ $\boxed{\text{ASD} = 469.8\,k}$

rgcmc

PROB # 3-34

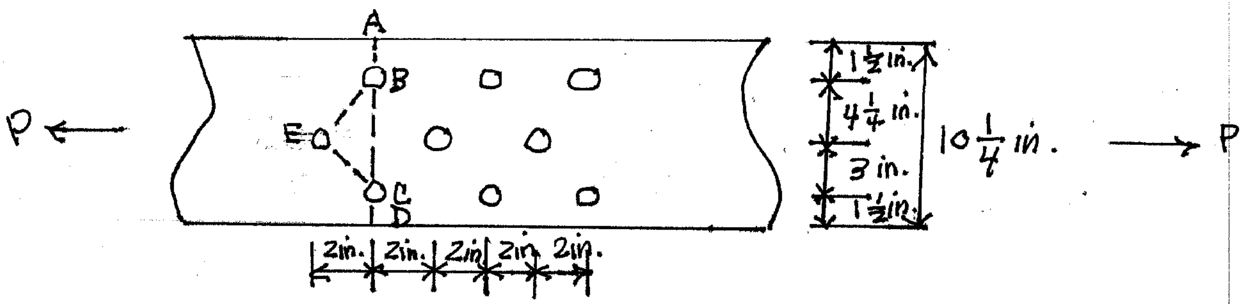
Using one L 7x4x$\frac{3}{4}$ (A_g = 7.69 in.^{2})

(a) Gross section yielding

$$P_n = F_y A_g = (36)(7.69) = 276.8 \text{ k}$$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(276.8) = 249.1 \text{ k}$	$\frac{P_n}{\Omega_t} = \frac{276.8}{1.67} = 165.7 \text{ k}$ ←

(b) Tensile rupture strength



Net widths

$$ABCD = 10.25 - (2)\left(\frac{7}{8}+\frac{1}{8}\right) = 8.25 \text{ in.}^2$$

$$ABECD = 10.25 - (3)\left(\frac{7}{8}+\frac{1}{8}\right) + \frac{(2)^2}{4\times 3} + \frac{(2)^2}{4\times 4.25}$$

$$= 7.818 \text{ in.} \leftarrow$$

$$A_n = (7.818)\left(\frac{3}{4}\right) = 5.86 \text{ in.}^2$$

$$U = 1.0$$

$$A_e = UA_n = (1.0)(5.86) = 5.86 \text{ in.}^2$$

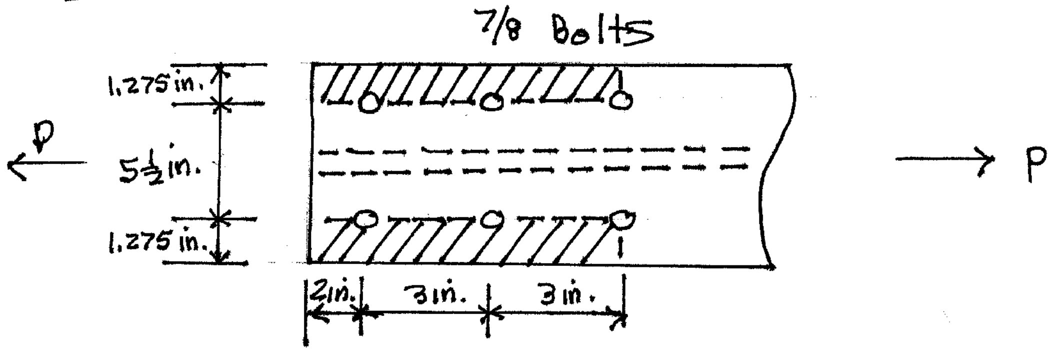
$$P_n = (58)(5.86) = 339.9 \text{ k}$$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(339.9) = 254.9 \text{ k}$	$\frac{P_n}{\Omega_t} = \frac{339.9}{2.00} = 169.9 \text{ k}$

Answers $\boxed{\text{LRFD} = 249.1 \text{ k}}$ $\boxed{\text{ASD} = 165.7 \text{ k}}$

✓ JCMc

PROB # 3-35



using a W12 x 45 ($t_f = 0.575$ in., $b_f = 8.05$ in.)

$$A_{gv} = (4)(8)(0.575) = 18.4 \text{ in.}^2$$

$$A_{nv} = (4)\left[8 - (2.5)\left(\tfrac{7}{8} + \tfrac{1}{8}\right)\right](0.575) = 12.65 \text{ in.}^2$$

$$A_{nt} = (4)\left[1.275 - \left(\tfrac{1}{2}\right)\left(\tfrac{7}{8} + \tfrac{1}{8}\right)\right](0.575) = 1.78 \text{ in.}^2$$

$$U_{bs} = 1.0$$

$$R_n = 0.6 F_u A_{nv} + U_{bs} F_u A_{nt} \le 0.6 F_y A_{gv} + U_{bs} F_u A_{nt}$$

$$= (0.6)(70)(12.65) + (1.0)(70)(1.78) = 655.9 \text{ k}$$

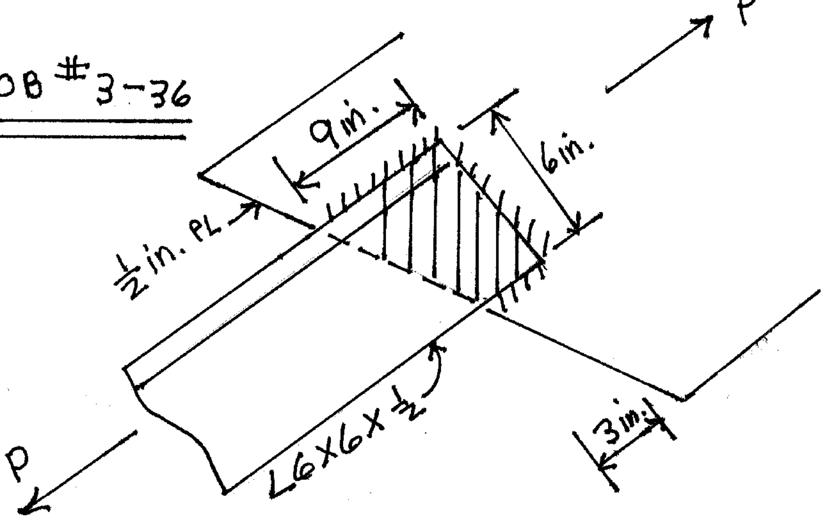
$$< (0.6)(50)(18.4) + (1.0)(70)(1.78) = 676.6 \text{ k}$$

$$\therefore R_n = 655.9 \text{ k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(655.9) = 491.9$ k	$\frac{R_n}{\Omega} = \frac{655.9}{2.00} = 327.9$ k

ANSWRS. $\boxed{\text{LRFD} = 491.9 \text{ k}}$ $\boxed{\text{ASD} = 327.9 \text{ k}}$

PROB # 3-36



using one L $6 \times 6 \times \frac{1}{2}$

$A_{gv} = (\frac{1}{2})(9+3) = 6.0 \text{ in.}^2$

$A_{nv} = (\frac{1}{2})(9+3) = 6.0 \text{ in.}^2$

$A_{nt} = (\frac{1}{2})(6) = 3.0 \text{ in.}^2$

$U_{bs} = 1.0$

$R_n = 0.6 F_u A_{nv} + U_{bs} F_u A_{nt} \leq 0.6 F_y A_{gv} + U_{bs} F_u A_{nt}$

$= (0.6)(65)(6.0) + (1.0)(65)(3.0) = 429 k$

$> (0.6)(50)(6.0) + (1.0)(65)(3.0) = 375 k \leftarrow$

$\therefore R_n = 375 k$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(375) = 281.2 k$	$\frac{R_n}{\Omega} = \frac{375}{2.00} = 187.5 k$

ANSWRS. $\boxed{\text{LRFD} = 281.2 k}$ $\boxed{\text{ASD} = 187.5 k}$

JCMc

PROB #3-37

Using a W16X31 ($A_g = 9.13\text{ in.}^2$, $d = 15.9\text{ in.}$, $b_f = 5.53\text{ in.}$, $t_f = 0.440\text{ in.}$, $t_w = 0.275\text{ in.}$, $\bar{x} = \bar{y}$ for WT 8X15.5 $= 2.02\text{ in.}$)

(a) Gross section yielding

$P_n = F_y A_g = (50)(9.13) = 456.5\text{ k}$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(456.5) = 410.8\text{ k}$	$\frac{P_n}{\Omega_t} = \frac{456.5}{1.67} = 273.4\text{ k}$

(b) Tensile rupture strength

$A_n = 9.13 - (4)(\frac{7}{8} + \frac{1}{8})(0.440) = 7.37\text{ in.}^2$

$\bar{x} = \bar{y} = 2.02\text{ in.}$ from table for WT 8X15.5

$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{2.02}{6} = 0.663$

But $b_f = 5.53\text{ in.} < (\frac{2}{3})(15.9) = 10.6\text{ in.}$

$\therefore U = 0.85$

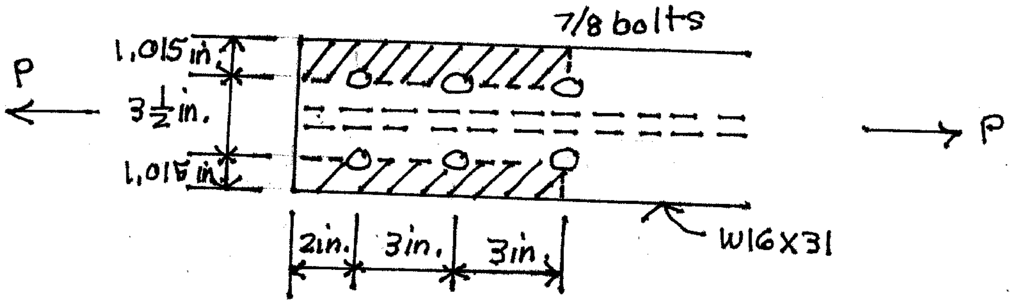
$A_e = U A_n = (0.85)(7.37) = 6.26\text{ in.}^2$

$P_n = F_u A_e = (65)(6.26) = 406.9\text{ k}$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(406.9) = 305.2\text{ k}$	$\frac{P_n}{\Omega_t} = \frac{406.9}{2.00} = 203.4\text{ k}$ ←

✓ JCMc

PROB # 3-37 CONTD.



$A_{gv} = (4)(8)(0.440) = 14.08 \text{ in.}^2$

$A_{nv} = (4)\left[8 - (2.5)\left(\frac{7}{8}+\frac{1}{8}\right)\right](0.440) = 9.68 \text{ in.}^2$

$A_{nt} = (4)\left[1.015 - \left(\frac{1}{2}\right)\left(\frac{7}{8}+\frac{1}{8}\right)\right](0.440) = 0.91 \text{ in.}$

$R_n = 0.6F_uA_{nv} + U_{bs}F_uA_{nt} \leq 0.6F_yA_{gv} + U_{bs}F_uA_{nt}$

$= (0.6)(65)(9.68) + (1.0)(65)(0.91) = 436.7k$

$< (0.6)(50)(14.08) + (1.0)(65)(0.91) = 481.5k$

$\therefore R_n = 436.7k$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(436.7) = 327.5k$	$\frac{R_n}{\Omega} = \frac{436.7}{2.00} = 218.3k$

ANSWRS. $\boxed{LRFD = 305.2k}$ $\boxed{ASD = 203.4k}$

rgcM ≡

CHAPTER 4

PROB #4-1

LRFD	ASD
$P_u = (1.2)(200) + (1.6)(300) = 720\,k$	$P_a = 200 + 300 = 500\,k$

(a) Min $A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{720}{(0.90)(50)} = 16 \text{ in.}^2$

(b) Assume $U = 0.90$ from AISC Table D3.1 Case 8 and assume $t_f =$ about 0.720 in. after studying AISC Table 1-1

min $A_g = \dfrac{P_u}{\phi_t F_u U}$ + estimated area of holes

$$= \frac{720}{(0.75)(65)(0.90)} + (4)(1+\tfrac{1}{8})(0.720) = 19.65 \text{ in.}^2$$

(c) Preferable min $r = \dfrac{L}{300} = \dfrac{12 \times 30}{300} = 1.20$ in.

Try W14x68 ($A = 20.0 \text{ in.}^2$, $d = 14.0$ in, $b_f = 10.0$ in., $t_f = 0.720$ in., $r_y = 2.46$ in.)

(a) $P_n = F_y A_g = (50)(20.0) = 1000\,k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(1000) = 900\,k > 720\,k$ ok	$P_n/1.67 = \dfrac{1000}{1.67} = 598.8\,k > 500\,k$ ok

vJcM^{c}

PROB # 4-1 CONTD.

(b) $\bar{y} = \bar{x}$ for WT7X34 $= 1.29$ in.

$L = (2)(4) = 8$ in.

$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{1.29}{8} = 0.84$

From AISC Table 3-2 $U = 0.90$ ←

since $b_f = 10.0 > \frac{2}{3}d = \frac{2}{3} \times 14.0 = 9.33$ in.

$A_n = 20.0 - (4)(1 + \frac{1}{8})(0.720) = 16.76 \text{ in.}^2$

$A_e = UA_n = (0.90)(16.76) = 15.08 \text{ in.}^2$

$P_n = F_u A_e = (65)(15.08) = 980.2$ k

LRFD	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(980.2) = 735.1 k > 720 k$ OK	$P_n/\Omega_t = \frac{980.2}{2.00} = 490.1 k < 500 k$ N.G.

(c) $\frac{L}{r_y} = \frac{12 \times 30}{2.46} = 146.3 < 300$ OK

$\boxed{\text{USE W14X68 for LRFD}}$ $\boxed{\text{USE W14X74 for ASD}}$

vgcm[c]

PROB # 4-2

LRFD	ASD
$P_u = (1.2)(200) + (1.6)(300) = 720\,k$	$P_a = 200 + 300 = 500\,k$

(a) $\text{Min } A_g = \frac{P_u}{\phi_t F_y} = \frac{720}{(0.9)(50)} = 16 \text{ in.}^2$

(b) Assume $U = 0.90$ from AISC Table D3.1 Case 7 and assume t_f = about 0.605 in. after studying AISC Table 1-1

$\text{Min. } A_g = \frac{P_u}{\phi_t F_u U}$ + estimated area of holes

$= \frac{720}{(0.75)(65)(0.90)} + (4)(1+\frac{1}{8})(0.605) = 19.13 \text{ in.}^2$

(c) Preferable min $r = \frac{L}{300} = \frac{(12)(30)}{300} = 1.20 \text{ in.}$

Try W12X65 ($A = 19.1 \text{ in.}^2$, $d = 12.1$ in., $b_f = 12.0$ in, $t_f = 0.605$ in., $r_y = 3.02$ in.)

(a) $P_n = F_y A_g = (50)(19.1) = 955\,k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(955) = 859.5\,k > 720\,k$ ok	$\frac{P_n}{\Omega_t} = \frac{955}{1.67} = 571.9\,k > 500\,k$ ok

PROB #4-2 CONTD.

(b) $\bar{y} = \bar{x}$ for a WT6x32.5 = 0.985 in.

$L = 2 \times 4 = 8$ in.

$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{0.985}{8} = 0.88$

From AISC Table 3-2 $U = 0.9$ since ←

$b_f = 12.0 \text{ in} > \frac{2}{3} \times d = \frac{2}{3} \times 12.1 = 8.07$ in.

$A_n = 19.1 - (4)(1 + \frac{1}{8})(0.605) = 16.38 \text{ in.}^2$

$A_e = A_n U = (16.38)(0.90) = 14.742 \text{ in.}^2$

$P_n = F_u A_e = (65)(14.742) = 958.23\text{ k}$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(958.23) = 718.7\text{ k} < 720\text{ k}$ Almost ok	$\frac{P_n}{\Omega_t} = \frac{958.23}{2.00} = 479.1\text{ k} < 500\text{ k}$ N.G.

(c) $\frac{L}{r} = \frac{(12)(20)}{3.02} = 79.5 < 300$ ok

$\boxed{\text{USE W12X72 for both LRFD and ASD}}$

✓ JCM^c

PROB # 4-3

LRFD	ASD
$P_u = 400k$	$P_a = 280k$

(a) $\text{Min } A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{400}{(0.9)(50)} = 8.89 \text{ in.}^2$

(b) Assume $U = 0.90$ from AISC Table D3.1 and assume flange t = about 0.515 in. after studying AISC Table 1-1

$$\text{Min } A_g = \frac{P_u}{\phi_t F_u U} + \text{estimated area of holes}$$

$$= \frac{400}{(0.75)(65)(0.90)} + (4)\left(\frac{7}{8} + \frac{1}{8}\right)(0.515) = 11.18 \text{ in.}^2 \leftarrow$$

(c) Preferable $\text{min } r = \dfrac{L}{300} = \dfrac{12 \times 28}{300} = 1.12 \text{ in.}$

Try W12x40 ($A = 11.7 \text{ in.}^2$, $d = 11.9$ in., $b_f = 8.01$ in., $t_f = 0.515$ in., $r_y = 1.94$ in.)

(a) $P_n = F_y A_g = (50)(11.7) = 585k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(585) = 526.5k > 400k$ ok	$\dfrac{P_n}{\Omega_t} = \dfrac{585}{1.67} = 350.3k > 280k$ ok

PROB # 4-3 CONTD.

(b) $\bar{y} = \bar{x}$ for WT6X20 $= 1.09$ in.

$L = (2)(4) = 8$ in.

$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{1.09}{8} = 0.86$

From AISC Table 3-2 $U = 0.90$

since $b_f = 8.01 > \frac{2}{3}d = \frac{2}{3} \times 11.9 = 7.93$ in.

$A_n = 11.7 - (4)(\frac{7}{8} + \frac{1}{8})(0.515) = 9.64$ in.

$A_e = U A_n = (0.90)(9.64) \quad 8.68$ in.^{2}

$P_n = F_u A_e = (65)(8.68) = 564.2$ k

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(564.2) = 423.1$ k > 400 k ok	$\frac{P_n}{\Omega_t} = \frac{564.2}{2.00} = 282.1$ k > 280 k ok

(c) $\frac{L}{r} = \frac{12 \times 28}{1.94} = 173.2 < 300$ ok

$\boxed{\text{USE W12X40 for both LRFD and ASD}}$

vgcm$^{\underline{c}}$

PROB # 4-4

LRFD	ASD
$P_u = (1.2)(60) + (1.6)(20) = 104\text{ k}$	$P_a = 60 + 20 = 80\text{ k}$

(a) Min $A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{104}{(0.90)(36)} = 3.21\text{ in.}^2$

(b) Assume $U = 0.90$ from AISC Table D3.1 Case 7 and assume flange t_f = about 0.359 in after studying AISC Table 1-3

Min $A_g = \dfrac{P_u}{\phi_t F_u U}$ + estimated area of holes

$= \dfrac{104}{(0.75)(58)(0.90)} + (2)\left(\frac{3}{4} + \frac{1}{8}\right)(0.359) = 3.29\text{ in.}^2$

(c) Preferable minimum $r = \dfrac{12 \times 20}{300} = 0.80\text{ in.}$

Try S6 × 12.5 ($A = 3.66\text{ in.}^2$, $d = 6.00\text{ in.}$, $b_f = 3.33\text{ in.}$, $t_f = 0.359\text{ in.}$, $r_y = 0.702\text{ in.}$)

(a) $P_n = F_y A_g = F_y A_g = (36)(3.66) = 131.8\text{ k}$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(131.8) = 118.6\text{ k} > 104\text{ k}$ OK	$\dfrac{P_n}{\Omega_t} = \dfrac{131.8}{1.67} = 78.9\text{ k} < 80\text{ k}$ N.G.

PROB #4-4 CONTD.

(b) $\bar{y} = \bar{x}$ for ST 3X6.25 $= 0.692$ in.

$L = 2 \times 4 = 8$ in.

$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{0.692}{8} = 0.91$ ←

or

From AISC Table D3.1 $U = 0.85$ since

$b_f = 3.33 \text{ in.} < \frac{2}{3}d = \frac{2}{3} \times 6.00 = 4.00$ in.

$A_n = 3.66 - (2)(\frac{3}{4} + \frac{1}{8})(0.359) = 3.03 \text{ in.}^2$

$A_e = A_n U = (3.03)(0.41) = 2.76 \text{ in.}^2$

$P_n = F_u A_e = (58)(2.76) = 160.1$ k

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(160.1) = 120k > 104k$ ok	$\frac{P_n}{\Omega_t} = \frac{160.1}{2.00} = 80k = 80k$ ok

(c) $\frac{L}{r} = \frac{(12)(20)}{0.702} = 341.9 > 300$ Somewhat high

Nevertheless USE S6X12.5 For ASD & LRFD

An alternative is to use S8X18.4 ($r = 0.827$ in.) if the designer feels $\frac{L}{r} = 341.9$ is too high

vjc m^c

PROB # 4-5

LRFD	LRFD
$P_u = (1.2)(60) + (1.6)(20) = 104\,k$	$P_a = 60 + 20 = 80\,k$

(a) $\text{Min } A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{104}{(0.9)(36)} = 3.21 \text{ in.}^2$

(b) Assume U = about 0.91

$$\text{min } A_g = \frac{P_u}{\phi_t F_u U} + \text{estimated hole areas}$$
$$= \frac{104}{(0.75)(58)(0.91)} + (2)\left(\frac{3}{4} + \frac{1}{8}\right)(0.375) = 3.28 \text{ in.}^2$$

(c) Preferable $\text{min } r = \dfrac{L}{300} = \dfrac{12 \times 20}{300} = 0.80 \text{ in.}$

Try MC 6x15.1 ($A = 4.44 \text{ in.}^2$, $d = 6.00$ in, $t_f = 0.475$ in, $r_y = 0.883$ in)

(a) $P_n = F_y A_g = (36)(4.44) = 159.8\,k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(159.8) = 143.8\,k > 104\,k$	$\dfrac{P_n}{\Omega_t} = \dfrac{159.8}{1.67} = 95.7\,k > 80\,k$ ok

PROB #4-5 CONTD.

(b) $\bar{x}$ for MC6 X 15.1 = 0.940

$L = (2)(4) = 8$ in.

$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{0.940}{8} = 0.88$

$A_n = 4.44 - (2)(\frac{3}{4} + \frac{1}{8})(0.475) = 3.61$ in.^{2}

$A_e = U A_n = (0.88)(3.61) = 3.18$ in.^{2}

$P_n = F_u A_e = (58)(3.18) = 184.4$ k

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(184.4) = 138.3k > 114k$	$\frac{P_n}{\Omega_t} = \frac{184.4}{2.00} = 92.2k > 80k$

(c) $\frac{L}{r} = \frac{12 \times 20}{0.883} = 271.8 < 300$ ok

A subsequent check for an MC6X12 shows its ok for LRFD but not for ASD.

$\boxed{\text{USE MC 6X12 LRFD and MC6X15.1 for ASD}}$

rgcmc

PROB # 4-6

LRFD	ASD
$P_u = (1.2)(100) + (1.6)(120) = 312\text{k}$	$P_a = 100 + 120 = 220\text{ k}$

(a) $\text{Min } A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{312}{(0.90)(50)} = 6.93 \text{ in.}^2$

(b) Assume $U = 0.90$ from AISC Table D3.1 Case 7 and assume $t_f = 0.491$ in. after studying AISC Table 1-3

$$\text{min } A_g = \frac{P_u}{\phi_t F_u U} + \text{estimated area of holes}$$

$$= \frac{312}{(0.75)(65)(0.90)} + (4)(1 + \tfrac{1}{8})(0.491) = 9.32 \text{ in}^2$$

(c) Preferable $\text{min } r = \dfrac{L}{300} = \dfrac{(12)(20)}{300} = 0.80$ in.

Try S10 x 35 ($A = 10.3 \text{ in.}^2$, $d = 10.00$ in., $b_f = 4.94$ in., $t_f = 0.491$ in., $r_y = 0.899$ in.)

(a) $P_n = F_y A_g = (50)(10.3) = 515\text{k}$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(515) = 463.5 > 312\text{k}$ ok	$\dfrac{P_n}{\Omega_t} = \dfrac{515}{1.67} = 308.4\text{k} > 220\text{k}$ ok

PROB #4-6 CONTD.

(b) $\bar{y} = \bar{x}$ for ST 5X17.5 = 1.56 in.

$L = 3 \times 3 = 9$ in.

$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{1.56}{9} = 0.83$

From AISC Table D3.1 $U = 0.85$ since

$b_f = 4.94$ in. $< \frac{2}{3} d = \frac{2}{3} \times 10 = 6.67$ in.

$A_n = 10.3 - (4)(1\frac{1}{8})(0.491) = 8.09$ in.^{2}

$A_e = A_n U = (8.09)(0.85) = 6.88$ in^2

$P_n = F_u A_e = (65)(6.88) = 447.2$ k

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(447.2) = 335.4 > 312$ k ok	$\frac{P_n}{\Omega_t} = \frac{447.2}{2.00} = 223.6$ k > 220 k ok

(c) $\frac{KL}{r} = \frac{(12)(20)}{0.899} = 267 < 300$ ok

$\boxed{\text{USE S10X35 FOR BOTH LRFD AND ASD}}$

✓ JCM

PROB # 4-7

LRFD	ASD
$P_u = (1.2)(100) + (1.6)(120) = 312\,k$	$P_a = 100 + 120 = 220\,k$

(a) Min. $A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{312}{(0.9)(36)} = 9.63\text{ in.}^2$

(b) Assume $U = 0.85$ after studying AISC Table 1-3 and Table 1-10

min. $A_g = \dfrac{P_u}{\phi_t F_u U}$ + estimated area of holes

$= \dfrac{312}{(0.75)(58)(0.85)} + (4)(1 + \frac{1}{8})(0.491) = 10.65\text{ in.}^2 \leftarrow$

(c) min. preferable $r = \dfrac{L}{300} = \dfrac{(12)(20)}{300} = 0.80\text{ in.}$

Try S12×40.8 ($A = 11.9\text{ in.}^2$, $b_f = 5.25\text{ in.}$, $t_f = 0.659\text{ in.}$

$r_y = 1.06\text{ in.}$)

Checking

(a) $P_n = F_y A_g = (36)(11.9) = 428.4\,k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(428.4) = 385.6\,k > 312\,k$	$\dfrac{P_n}{\Omega_t} = \dfrac{428.4}{1.67} = 256.5\,k > 220\,k$

(b) $\bar{x} = \bar{y} = 1.58\text{ in.}$ for ST6×20.4 (AISC Table 1-10)

$U = 1 - \dfrac{\bar{x}}{L} = 1 - \dfrac{1.58}{3 \times 3} = 0.824$

However AISC Table D3.1 Case 7 says $U = 0.85$

since $b_f = 5.25 < \frac{2}{3}d = 5.25 < 8$

PROB # 4-7 Contd

$\therefore$ Use $U = 0.85$

$A_n = 11.9 - (4)(1 + \frac{1}{8})(0.659) = 8.93 \text{ in.}^2$

$A_e = (0.85)(8.93) = 7.59 \text{ in.}^2$

$P_n = F_u A_e = (58)(7.59) = 440k$

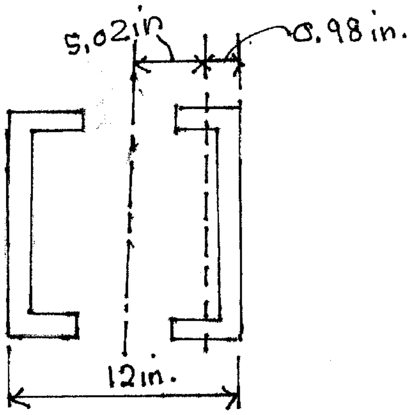
LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(440) = 330k > 312k$	$\frac{P_n}{\Omega_t} = \frac{440}{2.00} = 220k = 220k$

(c) $\frac{L}{r} = \frac{12 \times 20}{1.06} = 226k <$ preferable max = 300

Ans. $\boxed{\text{USE S12×40.8 for both LRFD and ASD}}$

v gcm^c

PROB # 4-8



LRFD	ASD
$P_u = (1.2)(150)+(1.6)(300) = 660\ k$	$P_a = 150+300 = 450\ k$

(a) $\text{min. } A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{660}{(0.9)(36)} = 20.37 \text{ in.}^2$

(b) $\text{min. } A_g = \dfrac{P_u}{\phi_t F_u U} = \dfrac{660}{(0.75)(58)(0.87)} = 17.44 \text{ in.}^2$

(c) Preferable $\text{min } r = \dfrac{L}{300} = \dfrac{(12)(30)}{300} = 1.20 \text{ in.}$

Try 2C13X35s (For each $A = 10.3 \text{ in.}^2$, $d = 13.0$ in., $I_x = 252 \text{ in.}^4$, $I_y = 12.3 \text{ in.}^4$, $\bar{x} = 0.980$ in.)

$I_x = (2)(252) = 504 \text{ in.}^4$

$r_x = \sqrt{\dfrac{504}{(2)(10.3)}} = 4.95 \text{ in.} \leftarrow$

$I_y = 2\left[12.3 + (10.3)(5.02)^2\right] = 568.3 \text{ in.}^4$

$r_y = \sqrt{\dfrac{568.3}{(2)(10.3)}} = 5.25 \text{ in.}$

PROB# 4-8 CONTD

Reviewing design

(a) $P_n = F_y A_g = (36)(2 \times 10.3) = 741.6\ k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(741.6) = 667.4k > 660k$	$\frac{P_n}{\Omega_t} = \frac{741.6}{1.67} = 444.1k < 450k$

N.G.

(b) $A_e = U A_n = U A_g$ for welded member

$= (0.87)(2 \times 10.3) = 17.92\ in.^2$

$P_n = F_u A_e = (58)(17.92) = 1039.4\ k$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(1039.4) = 779.5k > 660\ k$	$\frac{P_n}{\Omega_t} = \frac{1039.4}{2.00} = 519.7k > 450k$

(c) $\frac{L}{r} = \frac{(12)(30)}{4.95} = 72.7 <$ preferable value of 300

Ans. 2 MC 13x35s for LRFD, 2 MC 13x40s for ASD

✓ JCMC

PROB #4-9

LRFD	ASD
$P_u = (1.2)(100) + (1.6)(150) = 360\,k$	$P_a = 100 + 150 = 250\,k$

(a) $\text{Min. } A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{360}{(0.9)(50)} = 8.00 \text{ in.}^2$

(b) Assume $U = 0.85$ after studying AISC Tables 1-1 and 1-8

$$\text{Min. } A_g = \frac{P_u}{\phi_t F_u U} + \text{Estimated area of holes}$$

$$= \frac{360}{(0.75)(65)(0.85)} + (4)\left(\frac{3}{4} + \frac{1}{8}\right)(0.52) = 10.51 \text{ in.}^2$$

(c) $\text{Min. preferable } r = \dfrac{(12)(20)}{300} = 0.80 \text{ in.}$

Try W12X40 ($A = 11.7 \text{ in.}^2$, $d = 11.9$ in., $b_f = 8.01$ in., $t_f = 0.515$ in., $r_y = 1.94$ in., $\bar{x} = \bar{y}$ for WT6X20 $= 1.09$ in.)

Checking

(a) $P_n = F_y A_g = (50)(11.7) = 585\,k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(585) = 526.5\,k > 360\,k$	$\dfrac{P_n}{\Omega_t} = \dfrac{585}{1.67} = 350.3\,k > 250\,k$

(b) $U = 1 - \dfrac{\bar{x}}{L} = 1 - \dfrac{1.09}{(2)(3)} = 0.818$

But AISC Table D3.1 Case 7 shows we may use $U = 0.90$ since $b_f = 8.01 \text{ in.} > \frac{2}{3}d = \left(\frac{2}{3}\right)(11.9) = 7.93 \text{ in.}$

PROB # 4-9 CONTD.

$A_n = 11.7 - (4)(\frac{3}{4}+\frac{1}{8})(0.515) = 9.90 \text{ in.}^2$

$A_e = (0.90)(9.90) = 8.91 \text{ in.}^2$

$P_n = F_u A_e = (65)(8.91) = 579.2 k$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(579.2) = 434.6 k > 360 k$ ok	$\frac{P_n}{\Omega_t} = \frac{579.2}{2.00} = 289.6 k > 250 k$

(c) $\frac{L}{r} = \frac{(12)(20)}{1.94} = 123.7 <$ Preferable value of 300

Ans. USE W12X40 for both LRFD and ASD

rg cmc

PROB #4-10

LRFD	ASD
$P_u = (1.2)(200) + (1.6)(250) = 640k$	$P_a = 200 + 250 = 450k$

(a) Min. $A_g = \frac{P_u}{\phi_t F_y} = \frac{640}{(0.9)(50)} = 14.22 \text{ in.}^2$

(b) Assume $U = 0.90$ after study of AISC Table 1-1 & Table D3-1

Min. $A_g = \frac{P_u}{\phi_t F_u U}$ + Estimated hole areas

$= \frac{640}{(0.75)(65)(0.90)} + (4)(\frac{7}{8} + \frac{1}{8})(0.660) = 18.08 \text{ in.}^2$ ←

(c) Min preferable $r = \frac{12 \times 22}{300} = 0.88$ in.

Try W14X61 ($A = 17.9$ in.^{2}, $d = 13.9$ in., $b_f = 10.0$ in., $t_f = 0.645$ in., $r_y = 2.45$ in., $\bar{x} = \bar{y} = 1.25$ in. for WT 7X30.5)

Checking

(a) $P_n = F_y A_g = (50)(17.9) = 895k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(895) = 805.5k > 640k$	$\frac{P_n}{\Omega_t} = \frac{895}{1.67} = 535.9k > 450k$

(b) $U = 1 - \frac{\bar{x}}{L} = 1 - \frac{1.25}{8} = 0.84$

But $b_f = 10.00 > \frac{2}{3}d = (\frac{2}{3})(13.9) = 9.27$ in.

$\therefore U = 0.90$

$A_n = 17.9 - (4)(\frac{7}{8} + \frac{1}{8})(0.645) = 15.32 \text{ in.}^2$

$A_e = UA_n = (0.90)(15.32) = 13.79 \text{ in.}^2$

$P_n = F_u A_e = (65)(13.79) = 896.3k$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(896.3) = 672.2k > 640k$	$\frac{P_n}{\Omega_t} = \frac{896.3}{2.00} = 448k < 450k$

Ansr. $\boxed{\text{W14X61}}$ $\boxed{\text{W14X68}}$

PROB# 4-11

LRFD	ASD
$P_u = (1.2)(120) + (1.6)(100) = 304\,k$	$P_a = 120 + 100 = 220\,k$

(a) min. $A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{304}{(0.9)(50)} = 6.76$ in.^{2}

(b) min. A of flanges $= \dfrac{P_u}{\phi_t F_u U} = \dfrac{304}{(0.75)(65)(1.0)} = 6.24$ in.^{2}

(c) Preferable min. $r = \dfrac{12 \times 16}{3.00} = 0.64$ in.

Try W10X33 ($A = 9.71$ in.^{2}, $b_f = 7.96$ in., $t_f = 0.435$ in, $r_y = 1.94$ in.)

Checking

(a) $P_n = F_y A_g = (50)(9.71) = 485.5\,k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(485.5) = 436.9\,k > 304\,k$	$\dfrac{P_n}{\Omega_t} = \dfrac{485.5}{1.67} = 290.7\,k > 220\,k$

(b) $A_e = (1.00)(2$ flange areas$) = (1.00)(2 \times 7.96 \times 0.435) = 6.93$ in.^{2}

$P_n = F_u A_e = (65)(6.93) = 450.4\,k$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(450.4) = 337.8\,k > 304\,k$	$\dfrac{P_n}{\Omega_t} = \dfrac{450.4}{2.00} = 225.2\,k > 220\,k$

(c) $\dfrac{L}{r} = \dfrac{12 \times 16}{1.94} = 99 < 300$ ok

Ans. $\boxed{W10X33}$ $\boxed{W10X33}$

rJCMc

PROB # 4-12

LRFD	ASD
$P_u = (1.2)(450) + (1.6)(120) = 732\ k$	$P_a = 450 + 120 = 570\ k$

(a) Min. $A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{732}{(0.90)(36)} = 22.59\ in.^2 \leftarrow$

(b) Assume $U = 0.90$ after study of AISC Table 1-1 & Table D3-1

Min $A_g = \dfrac{P_u}{\phi_t F_u U}$ + Estimated A of holes

$= \dfrac{732}{(0.75)(58)(0.90)} + (4)(\frac{3}{4} + \frac{1}{8})(0.735) = 21.27\ in.^2$

(c) min preferable $r = \dfrac{(12)(24)}{300} = 0.96$ in.

Try W12X79 ($A = 23.2\ in.^2$, $d = 12.4$ in., $t_f = 0.735$ in., $r_y = 3.05$ in., $\bar{x} = \bar{y} = 1.06$ in. for a WT 6x39.5, $b_f = 12.1$ in.)

Checking

(a) $P_n = F_y A_g = (36)(23.2) = 835.2\ k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(835.2) = 751.7k > 732\ k$	$\dfrac{P_n}{\Omega_t} = \dfrac{835.2}{1.67} = 500.1 < 570\ k$ N.G.

(b) $U = 1 - \dfrac{\bar{x}}{L} = 1 - \dfrac{1.06}{4} = 0.735$

But AISC Table D3.1 Case 7 says $U = 0.90$ if $b_f > \frac{2}{3}d$

$b_f = 12.1 > \frac{2}{3} \times 12.4 = 8.27$ in. $\therefore U = 0.90$

$A_n = 23.2 - (4)(\frac{3}{4} + \frac{1}{8})(0.735) = 20.63\ in.^2$

$A_e = U A_n = (0.90)(20.63) = 18.57\ in.^2$

$P_n = F_u A_e = (58)(18.57) = 1077.1\ k$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(1077.1) = 807.8k > 732\ k$	$\dfrac{P_n}{\Omega_t} = \dfrac{1077.1}{2.00} = 538.5k < 570k$ N.G.

Ans. $\boxed{W12X79}$ $\boxed{W12X87}$

vgcmc

PROB # 4-13

LRFD	ASD
$P_u = (1.2)(110) + (1.6)(130) = 340\,k$	$P_a = 110 + 130 = 240\,k$

(a) Min $A_g = \frac{P_u}{\phi_t F_y} = \frac{340}{(0.9)(36)} = 10.49\ in.^2$

(b) $U = 1.0$ but only flange areas may be used (AISC Table D3.1, Case 3)

Min. A_g of flanges $= \frac{P_u}{\phi_t F_u U} = \frac{340}{(0.75)(58)(1.0)} = 7.82\ in.^2$

(c) Preferable min. $r = \frac{L}{300} = \frac{12 \times 18}{300} = 0.72\ in.$

Try W10x39 ($A = 11.5\ in.^2$, $b_f = 7.99\ in.$, $t_f = 0.530\ in.$, $r_y = 1.98\ in.$)

CHECKING

(a) $P_n = F_y A_g = (36)(11.5) = 414\,k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(414) = 372.6\,k > 340\,k$	$\frac{P_n}{\Omega_t} = \frac{414}{1.67} = 247.9\,k > 240\,k$

(b) $U = 1.0$ with A_n = total flange area

$A_e = A_n U = (2)(7.99)(0.530)(1.0) = 8.47\ in.^2$

$P_n = F_u A_e = (58)(8.47) = 491.3\,k$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(491.3) = 368.5\,k > 340\,k$	$\frac{P_n}{\Omega_t} = \frac{491.3}{2.00} = 245.6\,k > 240\,k$

(c) $\frac{L}{r} = \frac{(12)(18)}{1.98} = 109.1 < 300$

Ans. $\boxed{W10 \times 39}$ $\boxed{W10 \times 39}$

✓ JCMc

PROB #4-14

LRFD	ASD
$P_u = (1.2)(80) + (1.6)(120) = 288\text{ k}$	$P_a = 80 + 120 = 200\text{ k}$

(a) Min. $A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{288}{(0.90)(36)} = 8.89\text{ in.}^2 \leftarrow$

(b) Assume $U = 0.85$ from AISC Table D3.1 Case 7 and assume flange $t_f =$ about 0.491 in. after studying AISC Table 1-3

Min. $A_g = \dfrac{P_u}{\phi_t F_u U}$ + Estimated area of holes

$= \dfrac{288}{(0.75)(58)(0.85)} + (2)(1\tfrac{1}{8})(0.491) = 8.34\text{ in}^2$

(c) Min. $r_y = \dfrac{12 \times 24}{300} = 0.96\text{ in.}$

Try S 12 x 31.8 ($A = 9.31\text{ in.}^2$, $d = 12.0\text{ in.}$, $b_f = 5.00\text{ in.}$, $t_f = 0.544\text{ in.}$, $r_y = 1.00\text{ in.}$)

Checking

(a) $P_n = F_y A_g = (36)(9.31) = 335.2\text{ k}$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(335.2) = 301.7\text{ k} > 288\text{ k}$	$\dfrac{P_n}{\Omega_t} = \dfrac{335.2}{1.67} = 200.7\text{ k} > 200\text{ k}$

✓ JCM^c

PROB # 4-14 CONTD.

(b) $\bar{y} = \bar{x} = 1.51$ in. for ST 6X15.9

$L = 2 \times 4 = 8$ in.

$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{1.51}{8} = 0.81$

From AISC Table D3.1 $U = 0.85$ since

$b_f = 5.00$ in. $< \frac{2}{3} d = \frac{2}{3} \times 12.0 = 8.00$ in.

$A_n = 9.31 - (2)(1 + \frac{1}{8})(0.544) = 8.09$ in.^{2}

$A_e = A_n U = (8.09)(0.85) = 6.88$ in.^{2}

$P_n = F_u A_e = (58)(6.88) = 399$ k

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(399) = 299.2$k > 288k	$\frac{P_n}{\Omega_t} = \frac{399}{2.00} = 199.5$k ≈ 200k ok

(c) $\frac{L}{r} = \frac{12 \times 24}{1.00} = 288 < 300$ ok

Ansr. $\boxed{S\ 12X31.8}$ $\boxed{S\ 12X31.8}$

vgcm

PROB # 4-15

LRFD	ASD
$P_u = (1.2)(70) + (1.6)(110) = 260k$	$P_a = 70 + 110 = 180k$

(a) Min. $A_g = \frac{P_u}{\phi_t F_y} = \frac{260}{(0.9)(36)} = 8.02 \text{ in.}^2$

(b) Assume $U = 0.78$ after studying values in AISC Table 1-8 and assume t_f = about 0.720 in.

Min $A_g = \frac{P_u}{\phi_t F_u U}$ + estimated hole area

$= \frac{260}{(0.75)(58)(0.78)} + (2)(1 + \frac{1}{8})(0.720) = 9.28 \text{ in.}^2$

(c) Preferable min $r = \frac{L}{300} = \frac{(12)(18)}{300} = 0.72 \text{ in.}$

Try WT 7×34 ($A = 9.99 \text{ in.}^2$, $d = 7.02$ in., $t_f = 0.720$ in, $r_x = 1.81$ in.)

Checking

(a) $P_n = F_y A_g = (36)(9.99) = 359.6k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(359.6) = 323.6k > 260k$	$\frac{P_n}{\Omega_t} = \frac{359.6}{1.67} = 215.3k > 180k$

(b) $\bar{y} = \bar{x}$ for WT 7×34 = 1.29 in.

$L = 2 \times 4 = 8$ in.

$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{1.29}{8} = 0.84$

$A_n = 9.99 - (2)(1 + \frac{1}{8})(0.720) = 8.37 \text{ in.}^2$

$A_e = A_n U = (8.37)(0.84) = 7.03 \text{ in.}^2$

$P_n = F_u A_e = (58)(7.03) = 407.7k$

PROB # 4-15 CONTD.

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(407.7) = 305.8^k > 260^k$	$\frac{P_n}{\Omega_t} = \frac{407.7}{2.00} = 203.8^k > 180^k$

(c) $\frac{L}{r} = \frac{12 \times 18}{1.81} = 119.3 < 300$

A subsequent check shows a WT 7X30.5 will be satisfactory for LRFD & ASD

✓ JCMc

PROB # 4-16

LRFD	ASD
$P_u = (1.2)(120) + (1.6)(160) = 400k$	$P_a = 120 + 160 = 280\ k$

(a) $\text{Min. } A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{400}{(0.90)(50)} = 8.89 \text{ in.}^2$

(b) Assume $U = 0.90$ after studying AISC Table 1-8

$\text{Min. } A_g = \dfrac{P_u}{\phi_t F_u U} = \dfrac{400}{(0.75)(65)(0.90)} = 9.12 \text{ in}^2.$

(c) Preferable min. $r = \dfrac{(12)(18)}{300} = 0.72 \text{ in.}$

Try WT 6 X 32.5 ($A = 9.54 \text{ in.}^2$, $\bar{y} = 0.985$ in., $r_x = 1.47$ in.)

Checking

(a) $P_n = F_y A_g = (50)(9.54) = 477k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(477) = 429.3k > 400k$	$\dfrac{P_n}{\Omega_t} = \dfrac{477}{1.67} = 285.6k > 280k$

(b) $\bar{y} = \bar{x} = 0.985 \text{ in.}$

$U = 1 - \dfrac{\bar{x}}{L} = 1 - \dfrac{0.985}{10} = 0.90$

$A_n = 9.54 \text{ in.}^2$

$A_e = A_n U = (9.54)(0.90) = 8.59 \text{ in.}^2$

$P_n = F_u A_e = (65)(8.59) = 558.3k$

PROB # 4-16 CONTD

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(558.3) = 418.7k > 400k$	$\frac{P_n}{\Omega_t} = \frac{558.3}{2.00} = 279.1k \approx 280k$

(c) $\frac{L}{r} = \frac{(12)(18)}{1.47} = 147 < 300$ ok

Ans. $\boxed{\text{USE WT6X32.5 for both LRFD and ASD}}$

✓ JCM[c]

PROB # 4-17

LRFD	ASD
$P_u = (1.2)(50) + (1.6)(100) = 220\text{k}$	$P_a = 50 + 100 = 150\text{k}$

(a) $\text{Min. } A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{220}{(0.90)(36)} = 6.79 \text{ in.}^2$

(b) Assume $U = 0.80$ after studying AISC Table D3.1

$$\text{Min. } A_g = \frac{P_u}{\phi_t F_u U} + \text{Estimated hole area}$$

$$= \frac{220}{(0.75)(58)(0.80)} + \left(\frac{7}{8}+\frac{1}{8}\right)(t) = 6.32 \text{ in.}^2 + 1.0t$$

(c) Preferable min. $r = \dfrac{12 \times 20}{300} = 0.80$

Angle t (in.)	Area of one 1-in bolt hole (in.^{2})	Gross are reqd = larger of $\frac{P_u}{\phi_t F_y}$ or $\frac{P_u}{\phi_t F_u U}$ + est. hole area (in.^{2})	Lightest angle avail., its area (in.^{2}) and its least r (in.)
$\frac{1}{2}$	0.50	6.82	$L8 \times 8 \times \frac{1}{2}$ ($A = 7.75$ in.^{2}, $r_z = 1.59$ in.)
$\frac{9}{16}$	0.562	6.882	$L8 \times 6 \times \frac{9}{16}$ ($A = 7.56$ in.^{2}, $r_z = 1.30$ in.)
$5/8$	0.625	6.945	$L8 \times 4 \times \frac{5}{8}$ ($A = 7.11$, $r_z = 0.8$[illegible] in.) ←
$3/4$	0.750	7.07	$L7 \times 4 \times \frac{3}{4}$ ($A = 7.69$ in.^{2}, $r_z = 0.855$)
$7/8$	0.875	7.195	$L6 \times 4 \times \frac{7}{8}$ ($A = 7.98$ in.^{2}, $r_z = 0.86$[illegible] in.) $L5 \times 5 \times \frac{7}{8}$ ($A = 7.98$ in.^{2}, $r_z = 0.971$)

PROB #4-17 CONTD.

Checking

Trying L8x4 x $\frac{5}{8}$ (A= in.^{2}, r_y= 1.06 in.

(a) $P_n = F_y A_g = (36)(\quad) = \quad k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(256) = 230.4k > 220k$	$\frac{P_n}{\Omega_t} = \frac{256}{1.67} = 153.3k > 150k$

(b) $\bar{x} = \bar{y} = 0.902$ in.

$U = 0.80$

or

$U = 1 - \frac{\bar{X}}{L} = 1 - \frac{0.902}{3 \times 3.5} = 0.914 \leftarrow$

$A_n = 7.11 - (1)(\frac{7}{8} + \frac{1}{8})(\frac{5}{8}) = 6.485$ in.^{2}

$P_n = F_u A_e = F_u U A_n = (58)(0.914 \times 6.485) = 343.8k$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(343.8) = 257.8k > 220k$	$\frac{P_n}{\Omega_t} = \frac{343.8}{2.00} = 171.9k > 150k$

(c) $\frac{L}{r} = \frac{12 \times 20}{0.856} = 280.4 < 300$ ok

Answer: $\boxed{\text{USE 1 L } 8 \times 4 \times \frac{5}{8} \text{ For both LRFD and ASD}}$

✓ JCMc

PROB #4-18

LRFD	ASD
$P_u = (1.2)(100) + (1.6)(150) = 360k$	$P_a = 100 + 150 = 250k$

(a) Min $A_g = \frac{P_u}{\phi_t F_y} = \frac{360}{(0.9)(50)} = 8.00 \text{ in.}^2$

(b) $u = 1.0$ but $A_n = A_e$ = area of direct connected elements per AISC Table D3.1 Case 3

Min. A_g of webs $= \frac{P_u}{\phi_t F_u U} = \frac{360}{(0.75)(65)(1.0)} = 7.38 \text{ in.}^2$

(c) Preferable min $r = \frac{L}{300} = \frac{(12)(20)}{300} = 0.80$

Try 2Cs 10X20 (For each channel $A_g = 5.87 \text{ in.}^2$, $d = 10.00$ in., $t_w = 0.379$ in., $I_x = 789 \text{ in.}^4$, $I_y = 2.80 \text{ in.}^4$)

Checking

(a) $P_n = F_y A_g = (50)(2 \times 5.87) = 587k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(587) = 528.3k > 360k$	$\frac{P_n}{\Omega_t} = \frac{587}{1.67} = 351.5k > 250k$

(b) 2 web areas $= (2)(10.00)(0.379) = 7.58 \text{ in.}^2 = A_e$

$P_n = F_u A_e = (65)(7.58) = 492.7k$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$	
$\phi_t P_n = (0.75)(492.7) = 369.5k > 360k$	$\frac{P_n}{\Omega_t} = \frac{492.7}{2.00} = 246.3k < 250k$	N.G.

(c) $I_x = (2)(78.9) = 157.8 \text{ in.}^2 \leftarrow$

$I_y = (2)[2.80 + (5.87)(5.606)^2] = 374.6 \text{ in.}^4$

$r_x = \sqrt{\frac{157.8}{(2)(5.87)}} = 3.67$ in.

$\frac{L}{r} = \frac{(12)(20)}{3.67} = 65.4 < 300$ ok

$\boxed{\text{USE 2Cs 10X20}}$ $\boxed{\text{USE 2Cs 10X25}}$

JCMc

PROB # 4-19

LRFD	ASD
$P_u = (1.2)(100) + (1.6)(150) = 360\,k$	$P_a = 100 + 50 = 150\,k$

(a) Min $A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{360}{(0.9)(50)} = 8.00\text{ in.}^2$

(b) Min. $A_g = \dfrac{P_u}{\phi_t F_u U}$ + Estimated area of holes

$= \dfrac{360}{(0.75)(65)(0.85)}$ + Estimated area of holes

(c) Preferable min $r = \dfrac{12 \times 20}{300} = 0.80$ in.

Angle t (in.)	Area of two 1-in. holes (in.²)	Gross area reqd = larger of $\frac{P_u}{\phi_t F_y}$ or $\frac{P_u}{\phi_t F_u U}$ + est area of holes (in.²)	Lightest pair of angles available, their areas (in.²) and their least r (in.)
$\frac{3}{8}$	0.75	9.44	—
$\frac{1}{2}$	1.00	9.69	2Ls 7X4X$\frac{1}{2}$ (A = 10.5 in.², r_x = 2.25 in.) ←
$\frac{5}{8}$	1.25	9.94	2Ls 6X4X$\frac{5}{8}$ (A = 11.7 in.², r_x = 1.89 in.)
$\frac{3}{4}$	1.50	10.19	2Ls 5X3$\frac{1}{2}$X$\frac{3}{4}$ (A = 11.6 in.², r_x = 1.55 in.)

Try 2Ls 7 X 4 X $\frac{1}{2}$ (A = 10.5 in.², r_x = 2.25 in.)

✓ JCM^c

PROB # 4-19 CONTD.

Checking

(a) $P_n = F_y A_g = (50)(10.5) = 525\,k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(525) = 472.5\,k > 360\,k$	$\frac{P_n}{\Omega_t} = \frac{525}{1.67} = 314.4\,k > 150\,k$

(b) $A_e = U A_n = 0.85\left[9.69 - (2)\left(\frac{7}{8}+\frac{1}{8}\right)\left(\frac{1}{2}\right)\right] = 7.39\text{ in.}^2$

$P_n = F_u A_e = (65)(7.39) = 480.3\,k$

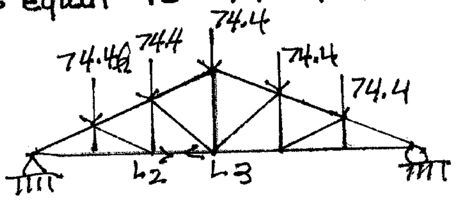
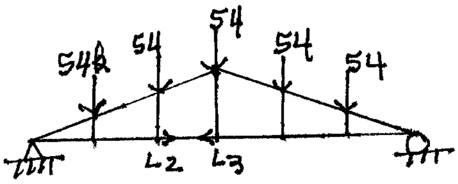
LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(480.3) = 360.2\,k > 360\,k$	$\frac{P_n}{\Omega_t} = \frac{480.3}{2.00} = 240.1\,k > 150\,k$

(c) $\frac{L}{r} = \frac{12 \times 20}{2.25} = 106.7 < 300$ ok

Ansr. $\boxed{\text{USE 2Ls } 7\times4\times\tfrac{1}{2} \text{ FOR BOTH LRFD and ASD}}$

JCMc

PROB #4-20

<table>
<tr><th>LRFD</th><th>ASD</th></tr>
<tr><td>Truss loads
$P_u = (1.2)(30) + (1.6)(24) = 74.4\text{k}$
By analysis of the truss force in member L_2L_3 is equal to 446.4k

</td><td>Truss loads
$P_a = 30 + 24 = 54\text{k}$
By analysis of the truss the force in member $L_2L_3 = 324\text{ k}$

</td></tr>
</table>

(a) min. $A_g = \dfrac{446.4}{(0.9)(36)} = 13.78 \text{ in.}^2$

(b) min. $A_g = \dfrac{P_u}{\phi_t F_u U}$ + Estimated area of holes

Assume U = about 0.8 after studying AISC Table D3.1

Min. $A_g = \dfrac{446.4}{(0.75)(58)(0.8)} + (2)\left(\frac{3}{4} + \frac{1}{8}\right)(\text{estimated } \frac{3}{4} \text{ in.}) = 14.14 \text{ in.}^2$

(c) min. preferable $r = \dfrac{L}{300} = \dfrac{(12)(12)}{300} = 0.48 \text{ in.}$

After studying double angle tables (AISC 1-15)

Try 2Ls $8 \times 4 \times \frac{5}{8}$ ($A = 14.3 \text{ in.}^2$, $\bar{x} = 0.902$, $r_y = 1.52$)

Checking

(a) $P_n = F_y A_g = (36)(14.3) = 514.8\text{k}$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t = (0.90)(514.8) = 463.3\text{k} > 446.4\text{k}$	$\dfrac{P_n}{\Omega_t} = \dfrac{514.8}{1.67} = 308.3\text{k} < 324\text{k}$ NG

PROB # 4-2D CONT'D

(b) $U = 1 - \frac{\bar{x}}{L} = 1 - \frac{0.902}{2 \times 4} = 0.89$

$A_n = 14.3 - (4)(\frac{3}{4} + \frac{1}{8})(\frac{5}{8}) = 12.11 \text{ in.}^2$

$P_n = F_u U A_n = (58)(0.89)(12.11) = 625.1 \text{ k}$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(625.1) = 468.8 \text{ k} > 446.4 \text{ k}$	$\frac{P_n}{\Omega_t} = \frac{625.1}{2.00} = 312.5 \text{ k} < 324 \text{ k}$

N.G.

(c) $\frac{L}{r} = \frac{(12)(12)}{1.52} = 94.7 < 300$ ok

ANS.

$\boxed{\text{USE 2Ls } 8 \times 4 \times \frac{5}{8} \text{ For LRFD}}$

$\boxed{\text{USE 2Ls } 8 \times 4 \times \frac{3}{4} \text{ For ASD}}$

JCMc

PROB # 4-21

LRFD	ASD
$P_u = (1.2)(70) + (1.6)(90) = 228\text{ k}$	$P_a = 70 + 90 = 160\text{ k}$

(a) $\text{Min. } A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{228}{(0.90)(42)} = 6.03\text{ in.}^2$

(b) Assume $U = 0.80$ (Case 8 AISC Table D3.1)

$\text{Min. } A_g = \dfrac{P_u}{\phi_t F_u U}$ + Estimated area of one bolt hole

$= \dfrac{228}{(0.75)(60)(0.80)} + (1)(\frac{7}{8} + \frac{1}{8})(\text{angle } t)$

$= 6.33\text{ in.}^2 + 1.0\,t$

(c) Preferable $\text{min. } r = \dfrac{12 \times 20}{300} = 0.80\text{ in.}$

Angle t (in.)	Area of one 1-in. bolt hole (in.^{2})	Gross area reqd = larger of $\frac{P_u}{\phi_t F_y}$ or $\frac{P_u}{\phi_t F_u U}$ plus est. hole area (in.^{2})	Lightest angle available, its area (in.^{2}) and its least radius of gyration (in.)
$\frac{1}{2}$	0.500	6.83	1 L 8x8x$\frac{1}{2}$ ($A = 7.75$, $r_z = 1.59$)
$\frac{9}{16}$	0.56	6.89	1 L 8x6x$\frac{9}{16}$ ($A = 7.56$, $r_z = 1.30$)
$\frac{5}{8}$	0.625	6.95	1 L 8x4x$\frac{5}{8}$ ($A = 7.11$, $r_z = .856$)
$\frac{3}{4}$	0.750	7.08	1 L 7x4x$\frac{3}{4}$ ($A = 7.69$, $r_z = .859$)
$\frac{7}{8}$	0.875	7.20	1 L 5x5x$\frac{7}{8}$ ($A = 7.98$ $r_z = 0.971$) 1 L 6x4x$\frac{7}{8}$ ($A = 7.98$, $r_z = 0.854$)

Try 1 L 8x4x$\frac{5}{8}$ ($A = 7.11\text{ in.}^2$, $r_z = 0.856\text{ in.}$)

PROB # 4-21 CONTD

Checking

(a) $P_n = F_y A_g = (42)(7.11) = 298.6\,k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(298.6) = 268.7\,k > 228\,k$	$\frac{P_n}{\Omega_t} = \frac{298.6}{1.67} = 178.8\,k > 160\,k$

(b) $U = 0.80$ or $1 - \frac{\bar{x}}{L} = 1 - \frac{0.902}{3 \times 4} = \underline{\underline{0.925}}$

$P_n = F_u A_e = (60)\left[7.11 - \left(\frac{7}{8} + \frac{1}{8}\right)(0.625)\right](0.925) = 359.9\,k$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(359.9) = 269.9\,k > 228\,k$	$\frac{P_n}{\Omega_t} = \frac{359.9}{2.00} = 179.9\,k > 160\,k$

(c) $\frac{L}{r} = \frac{(12)(20)}{0.856} = 280.4 < 300$

Ans. $\boxed{\text{USE 1 L } 8 \times 4 \times \tfrac{5}{8} \text{ For Both LRFD and ASD}}$

✓ JCMc

PROB #4-22

LRFD	ASD
$P_u = (1.2)(150) + (1.6)(300) = 660k$	$P_a = 150 + 300 = 450k$

(a) Min. $A_g = \frac{P_u}{\phi_t F_y} = \frac{660}{(0.90)(36)} = 20.37 \text{ in.}^2$

(b) Assume $\bar{x}$ = about 0.79 after examining AISC Table 1-5

Then $U = 1 - \frac{0.79}{(2)(4)} = 0.90$

Min. $A_g = \frac{P_u}{\phi_t F_u U}$ + Estimated area of holes

$= \frac{660}{(0.75)(58)(0.90)} + (4)\left(\frac{3}{4} + \frac{1}{8}\right)(\text{estimated } 0.520) = 18.68 \text{ in.}^2$

(c) Min. $r = \frac{12 \times 30}{300} = 1.20 \text{ in.}$

Try 2Cs 15x40 ($A = 11.8 \text{ in.}^2$, $t_w = 0.520$ in., $\bar{x} = 0.778$ in., $I_x = 348 \text{ in.}^4$, $I_y = 9.17 \text{ in}^4$ all for one channel)

Checking

(a) $P_n = F_y A_g = (36)(2 \times 11.8) = 849.6\ k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(849.6) = 764.6k > 660k$	$\frac{P_n}{\Omega_t} = \frac{849.6}{1.67} = 508.7k > 450k$

PROB # 4-22 CONTD.

(b) $U = 1 - \frac{\bar{x}}{L} = 1 - \frac{0.778}{2 \times 4} = 0.90$

$A_n = (2)(11.8) - (4)(3/4 + \frac{1}{8})(0.520) = 21.78 \text{ in.}^2$

$P_n = F_u A_e = F_u A_n U = (58)(21.78)(0.90) = 1136.9 \text{ k}$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi_t P_n = (0.75)(1136.9) = 852.7 \text{ k} > 660 \text{ k}$	$\frac{P_n}{\Omega_t} = \frac{1136.9}{2.00} = 568.4 \text{ k} > 450 \text{ k}$

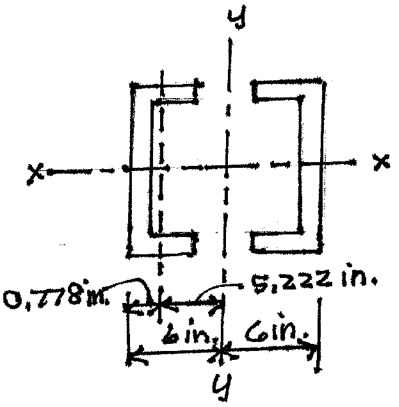
(c) $I_x = (2)(348) = 696 \text{ in.}^4$

$I_y = 2[9.17 + (11.8)(5.222)^2]$

$= 661.9 \text{ in.}^4$

$r_y = \sqrt{\frac{661.9}{(2)(11.8)}} = 5.30 \text{ in.}$

$\frac{L}{r} = \frac{12 \times 30}{5.30} = 67.9 < 300$



Ans. $\boxed{\text{USE 2Cs 15X40 For both LRFD and ASD}}$

r gcm

PROB #4-23

LRFD	ASD
$P_u = (1.2)(180) + (1.6)(320) = 728\ k$	$P_a = 180 + 320 = 500\ k$

(a) $\text{Min. } A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{728}{(0.9)(50)} = 16.18 \text{ in.}^2$

(b) As all legs are connected $U = 1.0$

$\text{Min. } A_g = \dfrac{P_u}{\phi_t F_u U}$ + estimated area of holes assuming angle $t = \frac{1}{2}$ in.

$= \dfrac{728}{(0.75)(65)(1.0)} + (8)\left(\frac{3}{4} + \frac{1}{8}\right)\left(\frac{1}{2}\right) = 18.43 \text{ in.}^2$

(c) Preferable min. $r = \dfrac{(12)(24)}{300} = 0.96$ in.

Angle t (in.)	Area of 8 $\frac{7}{8}$-in. holes (in.^{2})	A_g reqd (in)^2	Angles
$\frac{7}{16}$	3.06	17.99	4 Ls 6x6x$\frac{7}{16}$ (5.06 in.^{2} each)
$\frac{1}{2}$	3.50	18.43	4 Ls 5x5x$\frac{1}{2}$ (4.75 in^2 each) ←
$\frac{9}{16}$	3.94	18.87	4 Ls 6x6x$\frac{9}{16}$ (6.45 in.^{2} each)
$\frac{5}{8}$	4.38	19.31	4 Ls 5x5x$\frac{5}{8}$ (5.86 in.^{2} each)

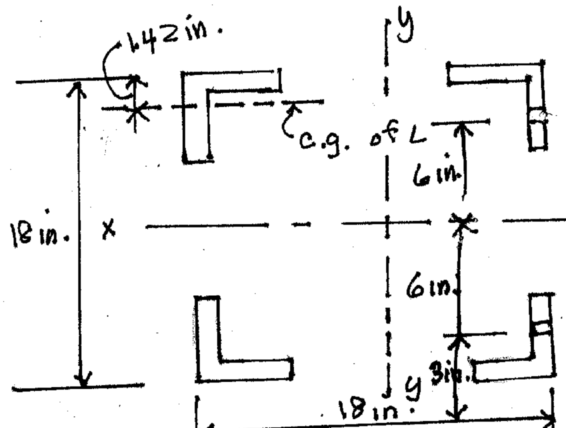
Try 4 Ls 5x5x$\frac{1}{2}$ ($A = 4 \times 4.75 = 19.0$ in.^{2})

Checking

(a) $P_n = (50)(19.0) = 950\ k$

LRFD $\phi_t = 0.90$	ASD $\Omega_t = 1.67$
$\phi_t P_n = (0.90)(950) = 855\ k > 728\ k$	$\dfrac{P_n}{1.67} = \dfrac{950}{1.67} = 568.9\ k > 500\ k$

PROB #4-23 CONTD.



$I_x = I_y = 4[11.3 + (4.75)(7.58)^2]$
$= 1137 \text{ in.}^4$

$r = \sqrt{\frac{1137}{19.0}} = 7.74 \text{ in.}$

(c) $\frac{L}{r} = \frac{12 \times 30}{7.74} = 46.5 < 300$
ok

(b) $U = 1.0$

$P_n = F_u A_e = (65)[19.00 - (8)(\frac{3}{4} + \frac{1}{8})(\frac{1}{2})] = 1007.5$

LRFD $\phi_t = 0.75$	ASD $\Omega_t = 2.00$
$\phi P_n = (0.75)(1007.5) = 755.6k > 728k$	$\frac{P_n}{\Omega_t} = \frac{1007.5}{2.00} = 503.7k > 500k$

Design of Tie Plates

Distance between bolt lines $= 18 - (2)(3) = 12$ in.
Min. length of PLs $= (\frac{2}{3})(12) = 8$ in.
Min. width of PLs $= 12 + (2)(1\frac{1}{2}) = 15$ in.
Min. t of PLs $= (\frac{1}{50})(12) = 0.24$ in. Say $\frac{1}{4}$ in.
Min. pref spacing of tie plates
r_z of 1 L $= 0.980$ in.
$\frac{12L}{0.980} = 300$
$L = 24.5$ ft

rgcm^c

Ans.

For both LRFD and ASD USE 4 Ls 5x5x$\frac{1}{2}$ with $\frac{1}{4}$x12x1ft 3in. tie PLs @ ℄ of span,

78

PROB # 4-24

LRFD	ASD
$P_u = (1.2)(10) + (1.6)(12) = 31.2\text{k}$	$P_a = 10 + 12 = 22\text{k}$

$$A_D \geq \frac{P_u}{\phi\, 0.75 F_u} = \frac{31.2}{(0.75)(0.75)(58)} = 0.956 \text{ in.}^2$$

Try $1\frac{1}{8}$ in. diameter rod from AISC Table 7-18 using the gross area of the rod 0.994 in.^2

$$R_n = 0.75 F_u A_D = (0.75)(58)(0.994) = 43.24\text{k}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = (0.75)(43.24) = 32.43\text{k} > 31.2\text{k}$ ok	$\frac{R_n}{\Omega} = \frac{43.24}{2.00} = 21.62\text{k} \simeq 22\text{k}$ ok

$\boxed{\text{use } 1\frac{1}{8} \text{ in. diameter rod with 7 threads per inch for LRFD and ASD}}$

✓ Jcm^c

PROB # 4-25

LRFD	ASD
$P_u = (1.2)(15) + (1.6)(18) = 46.8\text{ k}$	$P_a = 15 + 18 = 33\text{ k}$

$$A_D = \frac{P_u}{\phi\, 0.75 F_u} = \frac{46.8}{(0.75)(0.75)(58)} = 1.434\text{ in.}^2$$

Try $1\frac{3}{8}$ in. diameter rod from AISC Table 7-18 using the gross area of the rod (1.49 in.²)

$$R_n = 0.75 F_u A_D = (0.75)(58)(1.49) = 64.8\text{ k}$$

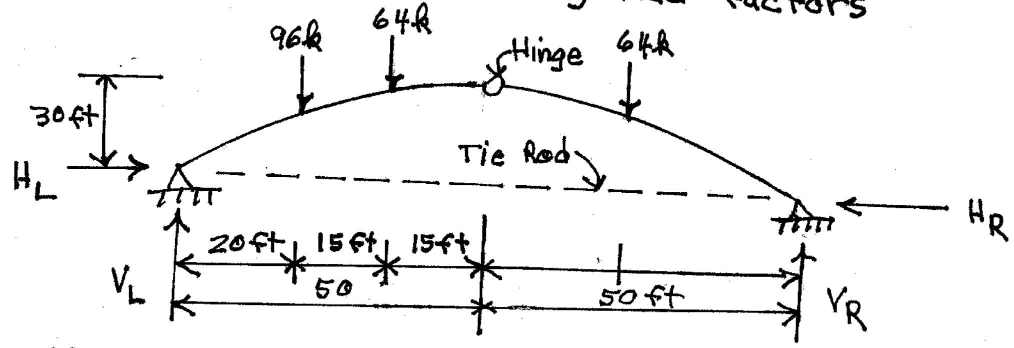
LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi_t R_n = (0.75)(64.8) = 48.6\text{ k} > 46.8\text{ k}$ ok	$\frac{R_n}{\Omega} = \frac{64.8}{2.00} = 32.4\text{ k} \approx 33\text{ k}$ ok

USE $1\frac{3}{8}$ in. diameter rod with 6 threads per inch for both LRFD and ASD

✓ J C McC

PROB #4-26

Multiplying service loads by load factors



$\Sigma M_L = 0$

$(96)(20) + (64)(35+70) - 100 V_R = 0$

$V_R = 86.4\,k \uparrow$

$V_L = 96 + (2)(64) - 86.4 = 137.6\,k \uparrow$

$\Sigma M_{\text{CROWN HINGE TO RIGHT}} = 0$

$(64)(20) - (86.4)(50) + 30 H_R = 0$

$H_R = 101.3\,k = H_L$

Going through same analysis with service loads

$H_R = 72.1\,k = H_L$

Select tie rod

$$A_D = \frac{P_u}{\phi\, 0.75\, F_u} = \frac{101.3}{(0.75)(0.75)(58)} = 3.10 \text{ in.}^2$$

Try 2 in. diameter rod from AISC Table 7-18 using the gross area of the rod $= 3.14$ in.^{2}

PROB # 4-26 Contd.

$$R_n = 0.75\,F_u A_D = (0.75)(58)(3.14) = 136.6\,k$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi P_n = (0.75)(136.6) = 102.4\,k > 101.3\,k$ ok	$\frac{R_n}{\Omega} = \frac{136.6}{2} = 68.3\,k < 72.1\,k$ NG

USE 2 in. diameter rod with $4\frac{1}{2}$ threads per in. for LRFD

USE $2\frac{1}{4}$ in. diameter rod with $4\frac{1}{2}$ threads per in. for LRFD

✓ JCMc

CHAPTER 5

PROB # 5-1

$$r = \sqrt{\frac{\left(\frac{1}{12}\right)(1)(1)^3}{1.0}} = 0.289 \text{ in.}$$

(a) L = 3 ft 6 in.

$$\frac{L}{r} = \frac{(12)(3.5)}{0.289} = 145.33$$

$$F_e = \frac{\pi^2 E}{\left(\frac{L}{r}\right)^2} = \frac{(\pi^2)(29\times10^3)}{(145.33)^2}$$

$$= 13.552 \text{ ksi} < 36 \text{ ksi}$$

$$P_{cr} = (13.552)(1.0) = \boxed{13.552 \text{ k}}$$

(b) L = 6 ft 0 in

$$\frac{L}{r} = \frac{(12)(6.0)}{0.289} = 249.13 > 200$$

$\boxed{\therefore \text{ Euler equation is not applicable as } \frac{L}{r} > 200}$

✓ JCMc

PROB # 5-2

$$A = \frac{(\pi)(8)^2}{4} - \frac{(\pi)(7)^2}{4} = 11.781 \text{ in.}^2$$

$$I = \frac{(\pi)(8)^4}{64} - \frac{(\pi)(7)^4}{64} = 83.20 \text{ in.}^4$$

$$r = \sqrt{\frac{83.20}{11.781}} = 2.66 \text{ in.}$$

(a) L = 27 ft 0 in.

$$\frac{L}{r} = \frac{(12)(27)}{2.66} = 121.80$$

$$F_e = \frac{(\pi)^2(E)}{\left(\frac{L}{r}\right)^2} = \frac{(\pi)^2(29\times10^3)}{(121.80)^2} = 19.293 \text{ ksi} < 36 \text{ ksi} \quad \underline{\text{ok}}$$

$$P_{cr} = (19.293)(11.781) = \boxed{227.3 \text{ k}}$$

(b) L = 18 ft 0 in.

$$\frac{L}{r} = \frac{(12)(18)}{2.66} = 81.20$$

$$F_e = \frac{\pi^2 E}{\left(\frac{L}{r}\right)^2} = \frac{(\pi)^2(29\times10^3)}{(81.20)^2} = 35.16 \text{ ksi} < 36 \text{ ksi} \quad \underline{\text{ok}}$$

$$P_{cr} = (35.16)(11.781) = \boxed{414.2 \text{ k}}$$

(c) L = 12 ft 0 in

$$\frac{L}{r} = \frac{(12)(12)}{2.66} = 54.14$$

$$F_e = \frac{\pi^2 E}{\left(\frac{L}{r}\right)^2} = \frac{(\pi)^2(29\times10^3)}{(54.14)^2} = 97.65 \text{ ksi} > 36 \text{ ksi} \quad \underline{\text{N.G}}$$

$\boxed{\therefore \text{ Euler equation does not apply}}$

✓ gcm[c]

PROB # 5-3

Using a W14 × 99 ($A = 29.1$ in.^{2}, $r_y = 3.71$ in.)

with L = 30 ft 0 in

$$\frac{L}{r} = \frac{(12)(30)}{3.71} = 97.04$$

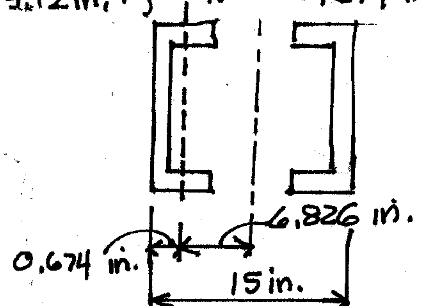
$$F_e = \frac{\pi^2 E}{\left(\frac{L}{r}\right)^2} = \frac{(\pi)^2(29\times10^3)}{(97.04)^2} = 30.39 \text{ ksi} < 36 \text{ ksi} \quad \text{ok}$$

$$P_{cr} = (30.39)(29.1) = \boxed{884.3\text{ k}}$$

✓ gcm^c

PROB # 5-4

Using 2C12X30s (For one C $A = 8.81$ in.^{2}, $I_x = 162$ in.^{4}, $I_y = 5.12$ in.^{4}, $\bar{x} = 0.674$ in.)



$$A_g = (2)(8.81) = 17.62 \text{ in.}^2$$

$$I_x = (2)(162) = 324 \text{ in.}^4$$

$$I_y = (2)\left[5.12 + (8.81)(6.826)^2\right] = 831.2 \text{ in.}^4$$

$$r_x = \sqrt{\frac{324}{17.62}} = 4.29 \text{ in.}$$

$$\frac{L}{r} = \frac{(12)(36)}{4.29} = 100.70$$

$$F_e = \frac{\pi^2 E}{\left(\frac{L}{r}\right)^2} = \frac{(\pi)^2(29\times10^3)}{(100.70)^2} = 28.23 \text{ ksi}$$

$$P_{cr} = (28.23)(17.62) = \boxed{497.4\text{ k}}$$

✓ gcm^c

PROB#5-5

Using a W10x45 ($A_g = 13.3$ in.^{4}, $r_y = 2.01$ in.)

$k = 1.0$ from AISC Table C-C2.2

$$\frac{kL}{r} = \frac{(1.0)(12 \times 15)}{2.01} = 89.55$$

$\phi_c F_{cr} = 25.035$ ksi
$\frac{F_{cr}}{\Omega_c} = 16.69$ ksi
From AISC Table 4-22 by interpolation

LRFD	ASD
$\phi_c P_n = (25.035)(13.3) = 333$ k	$\frac{P_n}{\Omega_c} = (16.69)(13.3) = 222$ k

Checking with AISC Table 4-1

$\phi_c P_n = 332$ k $\qquad \frac{P_n}{\Omega_c} = 221$ k

✓ JCMc

PROB#5-6

Using a W12x58 ($A_g = 17.0$ in.^{2}, $r_y = 2.51$ in.)

$k = 0.8$ from AISC C-C2.2

$KL = (0.8)(20) = 16$ ft

$$\frac{KL}{r} = \frac{(12)(16)}{2.51} = 76.49$$

$\phi_c F_{cr} = 29.35$ ksi
$\frac{F_{cr}}{\Omega_c} = 19.5$ ksi
From AISC Table 4-22 by interpolation

LRFD	ASD
$\phi_c P_n = (29.35)(17.0) = 499$ k	$\frac{P_n}{\Omega_c} = (19.5)(17.0) = 331.5$ k

Checking with AISC Table 4-1

$\phi_c P_n = 500$ k $\qquad \frac{P_n}{\Omega_c} = 333$ k

✓ JCMc

PROB #5-7

Using a W14×120 (A_g = 35.3 in.^{2}, r_y = 3.74 in.)

$$\frac{KL}{r} = \frac{(0.65)(12 \times 18)}{3.74} = 37.54$$

$\phi_c F_{cr}$ = 40.59 ksi
$\frac{F_{cr}}{\Omega_c}$ = 26.99 ksi
} From AISC Table 4-22

LRFD	ASD
$\phi_c P_n = (40.59)(35.3) = 1433 k$	$\frac{P_n}{\Omega_c} = (26.99)(35.3) = 953 k$ ←

Checking with AISC Table 4-1

$KL = (0.65)(18) = 11.7$ ft

$\phi_c P_n = 1436 k$ $\qquad$ $\frac{P_n}{\Omega_c} = 954 k$

√ gcmF

PROB #5-8

Using HSS 12×10×$\frac{3}{8}$ (A_g = 14.6 in.^{2}, r_y = 4.01 in.)

$$\frac{KL}{r} = \frac{(2.10)(12 \times 15)}{4.01} = 94.26$$

$\phi_c F_{cr}$ = 22.5 ksi
$\frac{F_{cr}}{\Omega_c}$ = 15.15 ksi
} From AISC Table 4-22

LRFD	ASD
$\phi_c P_n = (22.75)(14.6) = 332.2 k$	$\frac{P_n}{\Omega_c} = (15.15)(14.6) = 221.2 k$ ←

Checking with AISC Table 4-1

$KL = (2.10)(15) = 31.5$ ft

$\phi_c P_n = 331.5 k$ $\qquad$ $\frac{P_n}{\Omega_c} = 221 k$

√ gcmc

PROB # 5-9

(a) Using a W14X145 with KL = 14 ft

LRFD	ASD
$\phi_c P_n = 1690\,k$	$\frac{P_n}{\Omega_c} = 1120\,k$

Using AISC Table 4-1

(b) Using a W12X87 with KL = 18 ft

LRFD	ASD
$\phi_c P_n = 801\,k$	$\frac{P_n}{\Omega_c} = 533\,k$

Using AISC Table 4-1

(c) Using S15X42.9 ($A = 12.6\ in.^2$, $r_y = 1.06\ in.$)

$KL = 16\ ft$

$$\frac{KL}{r_y} = \frac{12 \times 16}{1.06} = 181.13$$

$$\phi_c F_{cr} = 6.89\ ksi$$

$$\frac{F_{cr}}{\Omega_c} = 4.58\ ksi$$

LRFD	ASD
$\phi_c P_n = (6.89)(12.6) = 86.8\,k$	$\frac{P_n}{\Omega_c} = (4.58)(12.6) = 57.7\,k$

PROB # 5-10

(a) Using a W14×82

$KL = (0.65)(16) = 10.4\ ft$

LRFD	ASD
$\phi_c P_n = 899.2\ k$	$\frac{P_n}{\Omega_c} = 598.2\ k$

(b) Using a W12×53

$KL = (1.00)(12.5) = 12.5\ ft$

LRFD	ASD
$\phi_c P_n = 536\ k$	$P_n/\Omega_c = 365.5\ k$

(c) Using a W10×68

$KL = (0.8)(18) = 14.4\ ft$

LRFD	ASD
$\phi_c P_n = 649.4\ k$	$\frac{P_n}{\Omega_c} = 432\ k$

(d) Using a W14×132 ($A = 38.8\ in.^2$, $r_y = 3.76\ in.$)

$$\frac{KL}{r_y} = \frac{(0.65)(12\times 20)}{3.76} = 41.49 < 4.71\sqrt{\frac{29\times 10^3}{65}} = 99.49$$

$$F_e = \frac{(\pi)^2(29\times 10^3)}{(41.49)^2} = 166.27\ ksi$$

$$F_{cr} = \left[0.658^{\frac{65}{166.27}}\right]65 = 55.19\ ksi$$

LRFD	ASD
$\phi_c F_{cr} = (0.9)(55.19) = 49.67\ ksi$ $\phi_c P_n = (49.67)(38.8) = 1927\ k$	$\frac{F_{cr}}{\Omega_c} = \frac{55.19}{1.67} = 33.05\ ksi$ $\frac{P_n}{\Omega_c} = (33.05)(38.8) = 1282\ k$

(e) Using a Pipe 12× strong

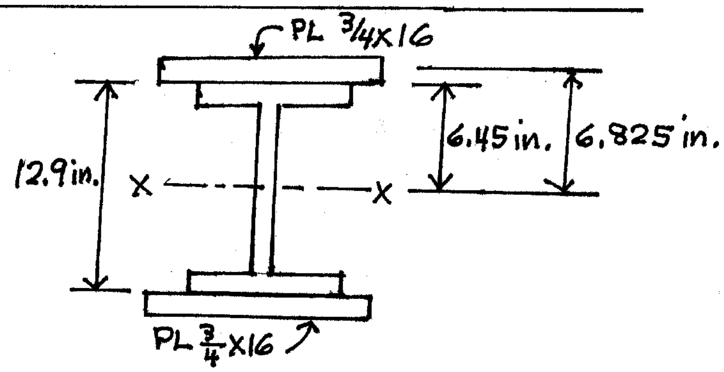
$KL = (1.0)(22) = 22\ ft$

LRFD	ASD
$\phi_c P_n = 468\ k$	$\frac{P_n}{\Omega_c} = 311\ k$

rgcm^c

PROB # 5-11

Using a W12x106 ($A = 31.2\ in.^2$, $d = 12.9\ in.$, $I_x = 933\ in.^4$, $I_y = 301\ in.^4$) plus 1 PL $\frac{3}{4}$x16 each flange



$$A_g = 31.2 + (2)(\tfrac{3}{4}\times 16) = 55.2\ in.^2$$

$$I_x = 933 + (2)(\tfrac{3}{4}\times 16)(6.825)^2 = 2051\ in.^2$$

$$I_y = 301 + (2)(\tfrac{1}{12}\times \tfrac{3}{4}\times 16^3) = 813\ in.^4$$

$$r_y = \sqrt{\frac{813}{55.2}} = 3.84\ in.$$

$$\frac{KL}{r} = \frac{(12)(18)}{3.84} = 56.25$$

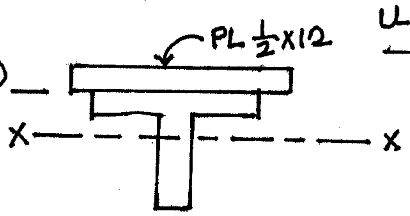
$$\left.\begin{array}{l} \phi_c F_{cr} = 35.725\ ksi \\ \dfrac{F_{cr}}{\Omega_c} = 23.75\ ksi \end{array}\right\} \text{From AISC Table 4-22}$$

LRFD	ASD
$\phi_c P_n = (35.725)(55.2) = 1972\ k$	$\frac{P_n}{\Omega_c} = (23.75)(55.2) = 1311\ k$

✓ gcm^c

PROB # 5.12

(a)



Using a WT 15x146 ($A = 42.9$ in.^{2}, $\bar{y} = 3.62$ in., $I_x = 861$ in.^{4}, $I_y = 549$ in.^{4})

$$A_g = \left(\tfrac{1}{2}\right)(12) + 42.9 = 48.9 \text{ in.}^2$$

$$y \text{ from top} = \frac{\left(\frac{1}{2}\right)(12)\left(\frac{1}{4}\right) + (42.9)\left(\frac{1}{2} + 3.62\right)}{48.9} = 3.645 \text{ in.}$$

$$I_x = \left(\tfrac{1}{12}\right)(12)\left(\tfrac{1}{2}\right)^3 + \left(\tfrac{1}{2}\right)(12)(3.395)^2 + 861 + (42.9)(0.745)^2 = 940 \text{ in.}^4$$

$$I_y = 549 + \left(\tfrac{1}{12}\right)\left(\tfrac{1}{2}\right)(12)^3 = 621 \text{ in.}^4$$

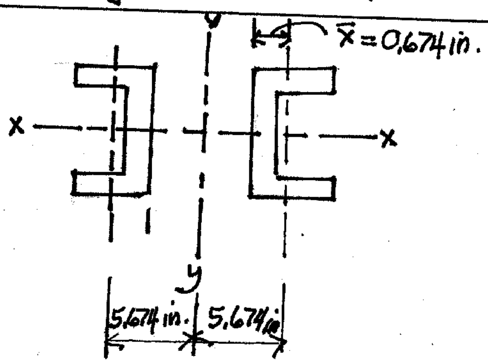
$$r_y = \sqrt{\frac{621}{48.9}} = 3.56 \text{ in.}$$

$$\frac{KL}{r} = \frac{(12)(28)}{3.56} = 94.38$$

$$\phi_c F_{cr} = 23.49 \text{ ksi}, \quad \frac{F_{cr}}{\Omega_c} = 15.62 \text{ ksi}$$

LRFD	ASD
$\phi_c P_n = (23.49)(48.9) = 1149$ k	$\frac{P_n}{\Omega_c} = (15.62)(48.9) = 764$ k

(b) Using 2 C12x30 (For each $A = 8.81$ in^2, $I_x = 162$ in.^{4}, $I_y = 5.12$ in.^{4})



$$A = (2)(8.81) = 17.62 \text{ in.}^2$$

$$I_x = (2)(162) = 324 \text{ in.}^4$$

$$I_y = (2)\left[5.12 + (8.82)(5.674)^2\right] = 578 \text{ in.}^4$$

$$r_x = \sqrt{\frac{324}{17.62}} = 4.29 \text{ in.}$$

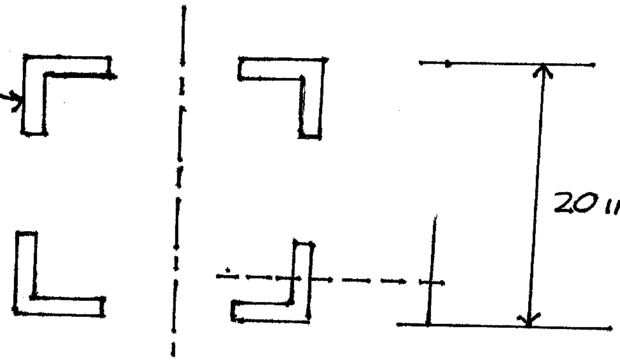
$$\frac{KL}{r} = \frac{(12)(22)}{4.29} = 61.54$$

$$\phi_c F_{cr} = 34.14 \text{ ksi}, \quad \frac{F_{cr}}{\Omega_c} = 22.69 \text{ ksi}$$

LRFD	ASD
$\phi_c P_n = (34.14)(17.62) = 601.5$ k	$\frac{P_n}{\Omega_c} = (22.69)(17.62) = 399.8$ k

PROB # 5-13(a)

L6X6X1
(A = 11.0 in.^{2}, $I_x = I_y$ = 35.4 in.^{4}, $\bar{y}$ = 1.86 in.)



$A = (4)(11.0) = 44.0 \text{ in.}^2$

$I_x = I_y = 4\left[35.4 + (11.0)(8.14)^2\right] = 3057 \text{ in.}^4$

$r_x = r_y = \sqrt{\frac{3057}{44.0}} = 8.34 \text{ in.}$

$\left(\frac{KL}{r}\right)_x = \left(\frac{KL}{r}\right)_y = \frac{(12)(22)}{8.34} = 31.65$

Referring to AISC Table 4-22

LRFD	ASD
$\phi_c F_{cr} = 41.84$ ksi	$\frac{F_{cr}}{\Omega_c} = 27.84$ ksi
$\phi_c P_n = (41.84)(44.0) = 1841$ k	$\frac{P_n}{\Omega_c} = (27.84)(44.0) = 1225$ k

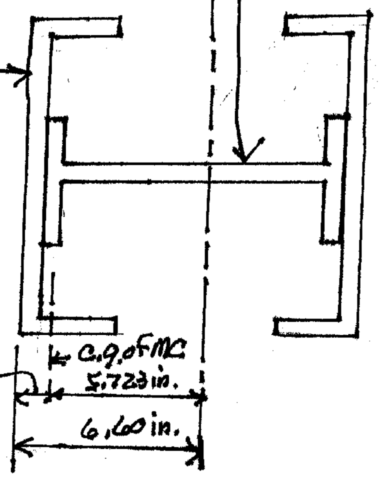
ANSWERS. $\boxed{1841\text{ k LRFD}}$ $\boxed{1225\text{ k ASD}}$

rjcm^c

PROB # 5-13(b)

W12X72 (A = 21.1 in.^{2}, d = 12.3 in., I_x = 597 in.^{4}, I_y = 195 in.^{4})

MC 18X42.7 (A = 12.6 in.^{2}, t_w = 0.450 in., I_x = 554 in.^{4}, I_y = 14.3 in.^{4}, $\bar{x}$ = 0.877 in.)



$$A = (2)(12.6) + 21.1 = 46.3 \text{ in.}^2$$

$$I_x = 195 + (2)(554) = 1303 \text{ in.}^4$$

$$I_y = 597 + 2[14.3 + (12.6)(5.723)^2] = 1451 \text{ in.}^4$$

$$r_x = \sqrt{\frac{1303}{46.3}} = 5.30 \text{ in.}$$

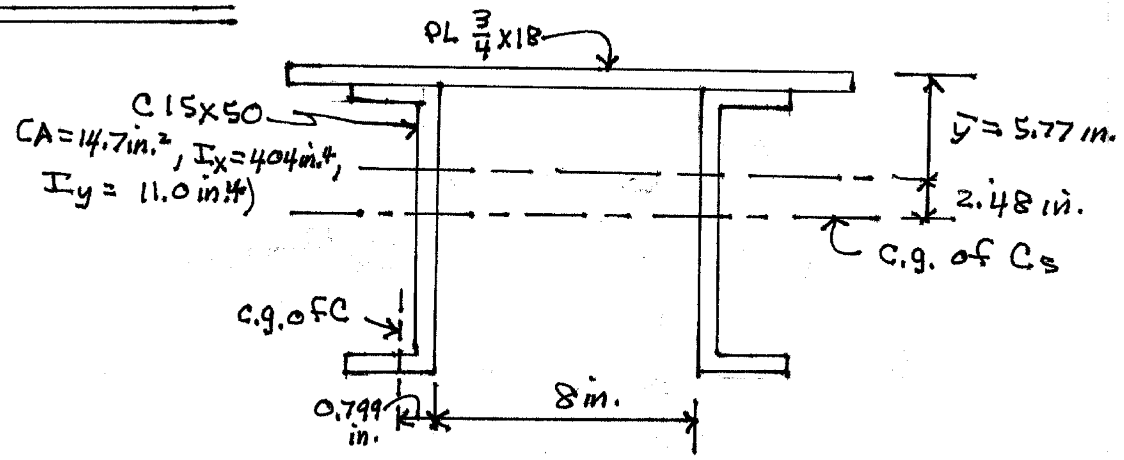
$$\left(\frac{KL}{r}\right)_x = \frac{(12)(18.5)}{5.30} = 41.89$$

LRFD	ASD
$\phi_c F_{cr}$ = 39.53 ksi (AISC Table 4-22)	$\frac{F_{cr}}{\Omega_c}$ = 26.32 ksi (AISC Table 4-22)
$\phi_c P_n$ = (39.53)(46.3) = 1830 k	$\frac{P_n}{\Omega_c}$ = (26.32)(46.3) = 1219 k

ANSWRS. $\boxed{1830 \text{ k LRFD}}$ $\boxed{1219 \text{ k ASD}}$

rgcm^c

PROB #5-14 (a)



$$A = \left(\tfrac{3}{4}\right)(18) + (2)(14.7) = 13.5 + 29.4 = 42.9 \text{ in.}^2$$

$$\bar{y} = \frac{(13.5)(0.375) + (2)(14.7)(8.25)}{42.9} = 5.77 \text{ in.}$$

$$I_x = (2)(404) + (2)(14.7)(2.48)^2 + (13.5)(5.395)^2 + \left(\tfrac{1}{12}\right)(18)\left(\tfrac{3}{4}\right)^3 = 1382 \text{ in.}^4$$

$$I_y = \left(\tfrac{1}{12}\right)\left(\tfrac{3}{4}\right)(18)^3 + 2\left[11.0 + (14.7)(4.799)^2\right] = 1063.6 \text{ in.}^4 \leftarrow$$

$$r_y = \sqrt{\frac{1063.6}{42.9}} = 4.98 \text{ in.}$$

$$\left(\frac{KL}{r}\right) = \frac{(12)(20)}{4.98} = 48.19$$

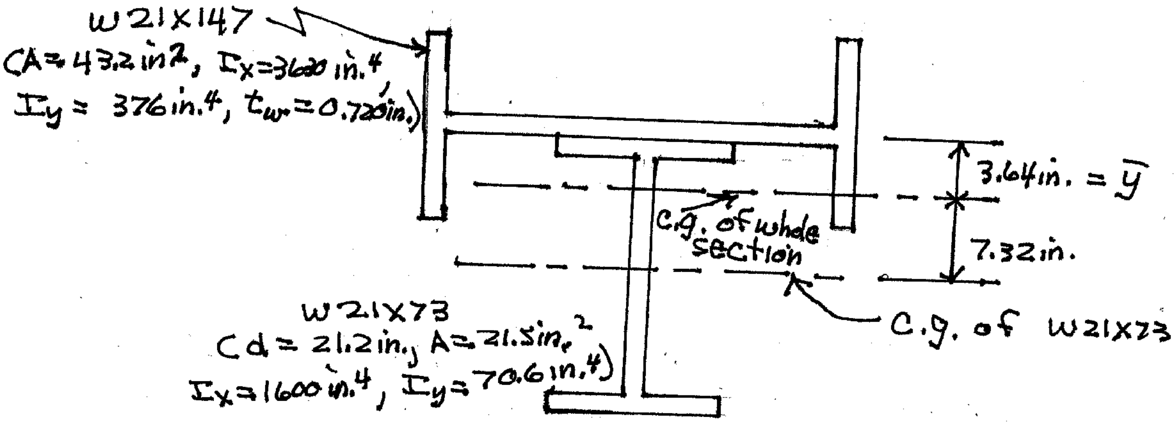
Referring to AISC Table 4-22

LRFD	ASD
$\phi_c F_{cr}$ = 37.94 ksi $\phi_c P_n = (37.94)(42.9) = 1628$ k	$\frac{F_{cr}}{\Omega_c}$ = 25.26 ksi $\frac{P_n}{\Omega_c} = (25.26)(42.9) = 1084$ k

ANSWRS $\boxed{1628 \text{ k LRFD}}$ $\boxed{1084 \text{ k ASD}}$

✓ JCMc

PROB# 5-14(b)



$A = 43.2 + 21.5 = 64.7 \text{ in.}^2$

$\bar{y} = \dfrac{(21.5)\left(\frac{0.720}{2} + \frac{21.2}{2}\right)}{64.7} = 3.64 \text{ in.}$

$I_x = 1600 + (21.5)(7.32)^2 + 376 + (43.2)(3.64)^2 = 3700 \text{ in.}^4 \leftarrow$

$I_y = 70.6 + 3630 = 3700.6 \text{ in.}^4$

$r_x = \sqrt{\dfrac{3700}{64.7}} = 7.56 \text{ in.}$

$\left(\dfrac{KL}{r}\right)_x = \dfrac{(12)(25)}{7.56} = 39.68$

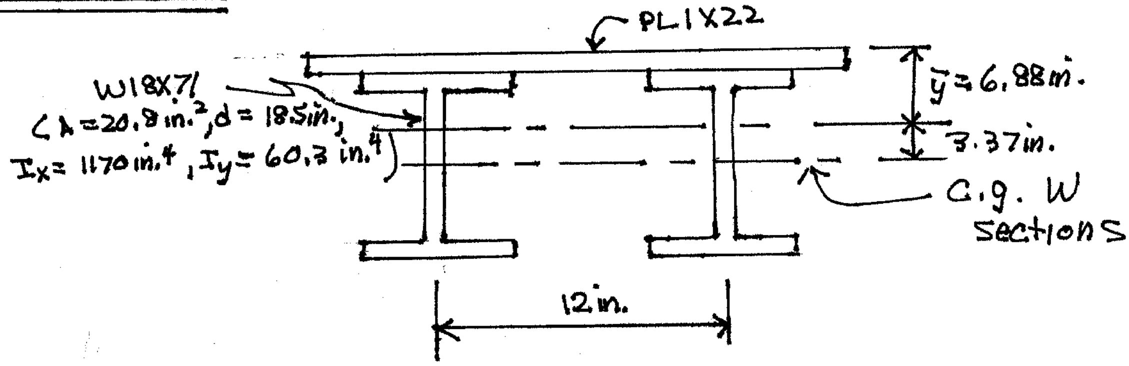
Referring to AISC Table 4-22

LRFD	ASD
$\phi_c F_{cr} = 40.10$ ksi $\phi_c P_n = (40.10)(64.7) = 2594$ k	$\dfrac{F_{cr}}{\Omega_c} = 26.66$ ksi $\dfrac{P_n}{\Omega_c} = (26.66)(64.7) = 1725$ k

ANSWRS. $\boxed{2594\text{k LRFD}}$ $\boxed{1725\text{k ASD}}$

✓ JCMc

PROB # 5-15(a)



$$A = (1)(22) + (2)(20.8) = 63.6 \text{ in.}^2$$

$$\bar{y} = \frac{(22)(0.5) + (2)(20.8)(10.25)}{63.6} = 6.88 \text{ in.}$$

$$I_x = 2\left[1170 + (20.8)(3.37)^2\right] + \left(\tfrac{1}{12}\right)(22)(1)^3 + (22)(6.38)^2$$

$$= 3710 \text{ in.}^4$$

$$I_y = \left(\tfrac{1}{12}\right)(1)(22)^3 + 2\left[60.3 + (20.8)(6)^2\right] = 2505.5 \text{ in.}^4$$

$$r_y = \sqrt{\frac{2505.5}{63.6}} = 6.28 \text{ in.}$$

$$\left(\frac{KL}{r}\right)_y = \frac{(0.8)(12 \times 20)}{6.28} = 30.57$$

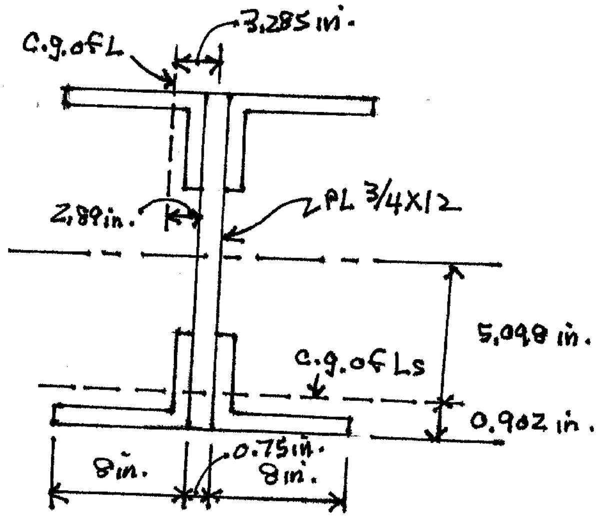
Referring to AISC Table 4-22

LRFD	ASD
$\phi_c F_{cr} = 41.97$ ksi	$\frac{F_{cr}}{\Omega_c} = 27.94$ ksi
$\phi_c P_n = (41.97)(63.6) = 2669$ k	$\frac{P_n}{\Omega_c} = (27.94)(63.6) = 1777$ k

ANSWRS. $\boxed{2669\text{k LRFD}}$ $\boxed{1777\text{k ASD}}$

vgcm

PROB # 5-15(b)



$A = (\frac{3}{4})(12) + (4)(7.11) = 37.44 \text{ in.}^2$

$I_x = (\frac{1}{12})(\frac{3}{4})(12)^3 + 4[8.11 + (7.11)(5.098)^2] = 879.6 \text{ in.}^4$

$I_y = (\frac{1}{12})(12)(\frac{3}{4})^3 + (4)[47.0 + (7.11)(3.265)^2] = 491.6 \text{ in.}^4$ ←

$r_y = \sqrt{\frac{491.6}{37.44}} = 3.62 \text{in.}$

$(\frac{KL}{r})_y = \frac{(2.1)(12\times28)}{3.62} = 194.92$

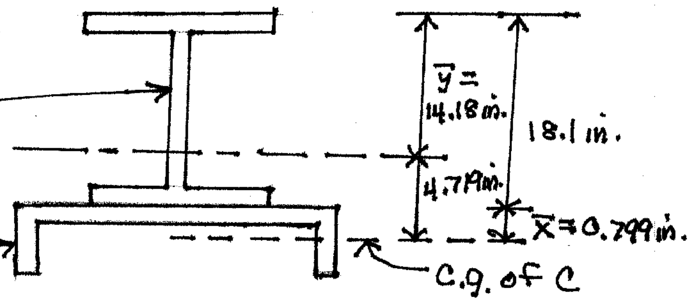
Referring to AISC Table 4-22.

LRFD	ASD
$\phi_c F_{cr} = 5.94$ ksi $\phi_c P_n = (5.94)(37.44) = 222.4$k	$\frac{F_{cr}}{\Omega_c} = 3.95$ ksi $\frac{P_n}{\Omega_c} = (3.95)(37.44) = 147.9$

ANSWRS. $\boxed{222.4\text{k LRFD}}$ $\boxed{147.9\text{k ASD}}$

vgcm©

PROB # 5-16 (a)



$A = 13.5 + 14.7 = 28.2 \text{ in.}^2$

$\bar{y} = \dfrac{(13.5)(9.05)+(14.7)(18.1+0.799)}{28.2} = 14.18 \text{ in.}$

$I_x = 712 + (13.5)(5.13)^2 + 11.0 + (14.7)(4.719)^2 = 1406 \text{ in.}^4$

$I_y = 22.5 + 404 = 426.5 \text{ in.}^4$ ←

$r_y = \sqrt{\dfrac{426.5}{28.2}} = 3.89 \text{ in.}$

$\left(\dfrac{KL}{r}\right)_y = \dfrac{(0.65)(12)(20)}{3.89} = 40.10$

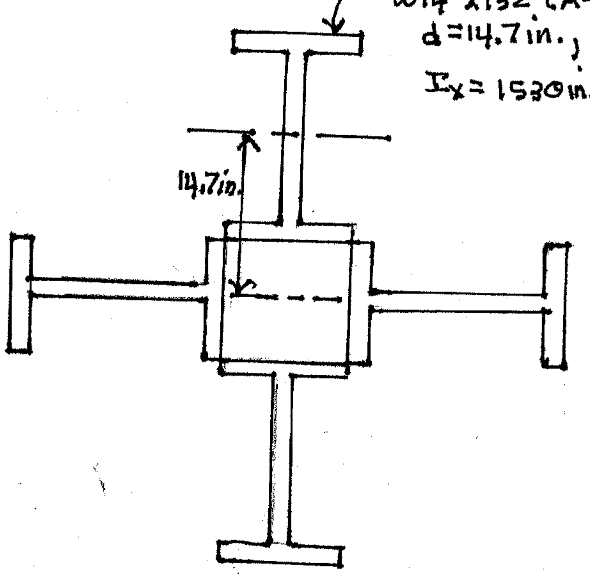
Referring to AISC Table 4-22

LRFD	ASD
$\phi_c F_{cr} = 39.98 \text{ ksi}$ $\phi_c P_n = (39.98)(28.2) = 1127 \text{k}$	$\dfrac{F_{cr}}{\Omega_c} = 26.59 \text{ ksi}$ $\dfrac{P_n}{\Omega_c} = (26.59)(28.2) = 750 \text{k}$

ANSWRS. $\boxed{1127 \text{k LRFD}}$ $\boxed{750 \text{k ASD}}$

✓ gcm

PROB # 5-16 (b)



$A = (4)(38.8) = 155.2 \text{ in.}^2$

$I_x = I_y = (2)\left[1530 + (38.8)(14.7)^2\right] + (2)(548) = 20{,}925 \text{ in.}^4$

$r_x = r_y = \sqrt{\dfrac{20{,}925}{155.2}} = 11.61 \text{ in.}$

$\left(\dfrac{KL}{r}\right)_x = \left(\dfrac{KL}{r}\right)_y = \dfrac{(1)(12)(40)}{11.61} = 41.34$

Referring to AISC Table 4-22

LRFD	ASD
$\phi_c F_{cr} = 39.70$ ksi	$\dfrac{F_{cr}}{\Omega_c} = 26.43$ ksi
$\phi_c P_n = (39.70)(155.2) = 6161$ k	$\dfrac{P_n}{\Omega_c} = (26.43)(155.2) = 4102$ k

ANSWRS.

$\boxed{6161 \text{ k LRFD}}$ $\boxed{4102 \text{ k ASD}}$

vjcmc

PROB# 5-17

Using a W10 x 112 ($A_g = 32.9$ in.^{2}, $r_x = 4.66$ in., $r_y = 2.68$ in.)

$$\left(\frac{KL}{r}\right)_x = \frac{(1.0)(12)(26)}{4.66} = 66.95 \leftarrow$$

$$\left(\frac{KL}{r}\right)_y = \frac{(1.0)(12)(13)}{2.68} = 58.21$$

From AISC Table 4-22

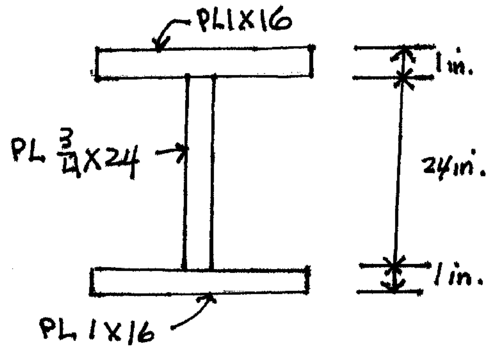
$\phi_c F_{cr} = 32.415$ ksi

$\frac{F_{cr}}{\Omega_c} = 21.61$ ksi

LRFD	ASD
$\phi_c P_n = (32.415)(32.9) = 1066.5$ k	$\frac{P_n}{\Omega_c} = (21.61)(32.9) = 711$ k

rgcm[c]

PROB # 5-18



$A = (2)(1 \times 16) + \frac{3}{4} \times 24 = 50 \text{ in.}^2$

$I_x = \left(\frac{1}{12}\right)(16)(26)^3 - \left(\frac{1}{12}\right)(15.25)(24)^3 = 5867 \text{ in.}^4$

$I_y = (2)\left(\frac{1}{12}\right)(1)(16)^3 + \left(\frac{1}{12}\right)(24)\left(\frac{3}{4}\right)^3 = 684 \text{ in.}^4$

$r_x = \sqrt{\frac{5867}{50}} = 10.83 \text{ in.}$

$r_y = \sqrt{\frac{684}{50}} = 3.70 \text{ in.}$

$\left(\frac{KL}{r}\right)_x = \frac{(12)(20)}{10.83} = 22.16$

$\left(\frac{KL}{r}\right)_y = \frac{(12)(14)}{3.70} = 45.41 \leftarrow$

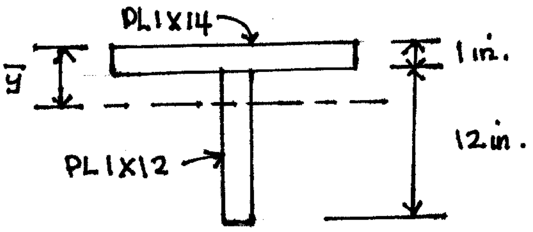
From AISC Table 4-22

$\phi_c F_{cr} = 38.68 \text{ ksi} \qquad \frac{F_{cr}}{\Omega_c} = 25.72 \text{ ksi}$

LRFD	ASD
$\phi_c P_n = (38.68)(50) = 1934 \text{ k}$	$\frac{P_n}{\Omega_c} = (25.72)(50) = 1286 \text{ k}$
Let S = service load	Let S = service load
$1934 = 1.2D + 1.6L$	$1286 = D + L$
$1934 = (1.2)\left(\frac{1}{3}S\right) + (1.6)\left(\frac{2}{3}S\right)$	$1286 = \frac{1}{3}S + \frac{2}{3}S$
$\boxed{S = 1318.6 \text{ k}}$	$\boxed{S = 1286 \text{ k}}$

rgcmc

PROB # 5-19



$A = (1)(14) + (1)(12) = 26\ in.^2$

$\bar{y} = \dfrac{(14)(0.5) + (12)(7)}{26} = 3.5\ in.$

$I_x = \left(\frac{1}{12}\right)(14)(1)^3 + (1 \times 14)(3.0)^2 + \left(\frac{1}{12}\right)(1)(12)^3 + (12)(3.5)^2 = 418.2\ in.^4$

$I_y = \left(\frac{1}{12}\right)(1)(14)^3 + \left(\frac{1}{12}\right)(12)(1)^3 = 229.7\ in.^4$

$r_x = \sqrt{\dfrac{418.2}{26}} = 4.01\ in.$

$r_y = \sqrt{\dfrac{229.7}{26}} = 2.97\ in.$

$\left(\dfrac{KL}{r}\right)_x = \dfrac{(12)(16)}{4.01} = 47.88 \leftarrow$

$\left(\dfrac{KL}{r}\right)_y = \dfrac{(12)(11)}{2.97} = 44.44$

Referring to AISC Table 4-22

LRFD	ASD
$\phi_c F_{cr} = 38.04$ ksi $\phi_c P_n = (38.04)(26) = 989.04$ k $(1.2)\left(\frac{3}{7}L\right) + 1.6L = 989.04$ $L = 466.8$ k	$\dfrac{F_{cr}}{\Omega_c} = 25.32$ ksi $\dfrac{P_n}{\Omega_c} = (25.32)(26) = 658.3$ k $\frac{3}{7}L + L = 658.3$ $L = 460.8$ k

ANSWRS $\boxed{466.8\text{k LRFD}}$ $\boxed{460.8\text{k ASD}}$ rgm^c

CHAPTER 6

PROB #6-1

LRFD	ASD
$P_u = (1.2)(150) + (1.6)(200) = 500\ k$	$P_a = 150 + 200\ k = 350\ k$
Assume $\frac{KL}{r} = 50$	Assume $\frac{KL}{r} = 50$
$\phi_c F_{cr}$ from AISC Table 4-22 $= 37.5$ ksi	$\frac{F_{cr}}{\Omega_c}$ from AISC 4-22 $= 24.9$ ksi
$A\ reqd = \frac{P_u}{\phi_c F_{cr}} = \frac{500}{37.5} = 13.39\ in^2$	$A\ reqd = \frac{P_a \Omega_c}{F_{cr}} = \frac{350}{24.9} = 14.06\ in.^2$
Try W14 X 48 ($A = 14.1\ in.^2$, $r_x = 5.85$ in., $r_y = 1.91$ in.)	Try W14X48 ($A = 14.1\ in.^2$, $r_x = 5.85$ in., $r_y = 1.91$ in.)
$\left(\frac{KL}{r}\right)_y = \frac{(12)(14)}{1.91} = 87.96$	$\left(\frac{KL}{r}\right)_y = \frac{(12)(14)}{1.91} = 87.96$
$\phi_c F_{cr}$ from AISC Table 4-22 $= 25.52$ ksi	$\frac{F_{cr}}{\Omega_c}$ from AISC Table 4-22 $= 17.01$ ksi
$\phi_c P_n = (25.52)(14.1) = 359.8\ k < 500\ k$ N.G.	$\frac{P_n}{\Omega_c} = (17.01)(14.1) = 239.8\ k < 350\ k$ N.G.
Try W14X61 ($A = 17.9\ in.^2$, $r_y = 2.45$ in)	Try W14X61 ($A = 17.9\ in.^2$, $r_y = 2.45$ in.)
$\left(\frac{KL}{r}\right)_y = \frac{(12)(14)}{2.45} = 68.57$	$\left(\frac{KL}{r}\right)_y = \frac{(12)(14)}{2.45} = 68.57$
$\phi_c F_{cr} = 31.93$ ksi	$\frac{F_{cr}}{\Omega_c} = 21.23$ ksi
$\phi_c P_n = (31.93)(17.9) = 571.5\ k > 500\ k$ OK	$\frac{P_n}{\Omega_c} = (21.23)(17.9) = 380\ k$
subsequent check of W14X53 shows it will not do.	Subsequent check of W14X53 shows it will not do.
$\boxed{\text{USE W14X61}}$	$\boxed{\text{USE W14X61}}$

VGCMc

PROB #6-2

LRFD	ASD
$P_u = (1.2)(200) + (1.6)(300) = 720k$	$P_a = 200 + 300 = 500k$
Assume $\frac{KL}{r} = 60$	Assume $\frac{KL}{r} = 60$
$\phi_c F_{cr} = 34.6$ ksi	$\frac{F_{cr}}{\Omega_c} = 23.0$ ksi
A Reqd $= \frac{720}{34.6} = 20.81$ in.^{2}	A reqd $= \frac{500}{23.0} = 21.74$ in.^{2}
Try W12×72 ($A = 21.1$ in.^{2}, $r_y = 3.04$)	Try W12×79 ($A = 23.2$ in.^{2}, $r_y = 3.05$ in)
$\left(\frac{KL}{r}\right)_y = \frac{(12)(16)}{3.04} = 63.16$	$\left(\frac{KL}{r}\right)_y = \frac{(12)(16)}{3.05} = 62.95$
$\phi_c F_{cr} = 33.65$ ksi	$\frac{F_{cr}}{\Omega_c} = 22.41$ ksi
$\phi_c P_n = (33.65)(21.1) = 710k$	$\frac{P_n}{\Omega_c} = (22.41)(23.2)$
$< 720k$ N.G.	$= 519.9k > 500$ OK
USE W12×79 by examination	USE W12×79

rgcm[c]

PROB # 6-3

LRFD	ASD
$P_u = (1.2)(200) + (1.6)(300) = 720\,k$	$P_a = 200 + 300 = 500\,k$
Assume $\frac{KL}{r} = 50$	Assume $\frac{KL}{r} = 50$
$\phi_c F_{cr} = 28.4$ ksi	$\frac{F_{cr}}{\Omega_c} = 18.9$ ksi
A Reqd $= \frac{720}{28.4} = 25.35\,in.^2$	A Reqd $= \frac{500}{18.9} = 26.46\,in.^2$
Try W12 x 87 ($A = 25.6\,in.^2$, $r_y = 3.07\,in$)	Try W12 x 96 ($A = 28.2\,in.^2$, $r_y = 3.09$)
$\left(\frac{KL}{r}\right)_y = \frac{12 \times 16}{3.07} = 62.54$	$\left(\frac{KL}{r}\right)_y = \frac{12 \times 16}{3.09} = 62.14$
$\phi_c F_{cr} = 26.39$ ksi	$\frac{F_{cr}}{\Omega_c} = 17.59$ ksi
$\phi_c P_n = (26.39)(25.6)$	$\frac{P_n}{\Omega_c} = (17.59)(28.2)$
$= 675.6\,k < 720\,k$ N.G.	$= 496\,k < 500\,k$ N.G.
USE W12X96	USE W12X106

VGC MC

PROB #6-4

LRFD	ASD
$P_u = (1.2)(150) + (1.6)(200) = 500^k$ From AISC Table 4-1 USE W14X61 ($\phi_c P_n = 572^k$)	$P_a = 150 + 200 = 350^k$ From AISC Table 4-1 USE W14X61 ($\frac{P_n}{\Omega_c} = 380^k$)

rgcm

PROB #6-5

LRFD	ASD
$P_u = (1.2)(200) + (1.6)(300) = 720^k$ From AISC Table 4-1 USE W12X79 ($\phi_c P_n = 781^k$)	$P_a = 200 + 300 = 500^k$ From AISC Table 4-1 USE W12X79 ($\frac{P_n}{\Omega_c} = 520^k$)

rgcm

PROB #6-6

LRFD	ASD
$P_u = (1.2)(250) + (1.60)(400) = 940^k$ From AISC Table 4-1 USE W12X96 ($\phi_c P_n = 957^k$)	$P_a = 250 + 400 = 650^k$ From AISC USE W12X106 ($\frac{P_n}{\Omega_c} = 706^k$)

rgcm

PROB #6-7

(a)

LRFD	ASD
$P_u = (1.2)(125) + (1.6)(200) = 470\ k$	$P_a = 125 + 200 = 325\ k$
$kL = (1)(15) = 15\ ft$	$kL = (1)(15) = 15\ ft$
$\boxed{W12 \times 53}$	$\boxed{W10 \times 54}$

vgcmc

(b)

LRFD	ASD
$P_u = (1.2)(100) + (1.6)(150) = 360\ k$	$P_a = 100 + 150 = 250\ k$
$kL = (0.65)(14) = 9.1\ ft$	$kL = (0.65)(14) = 9.1\ ft$
$\boxed{W8 \times 35}$	$\boxed{W10 \times 39}$

vgcmc

(c)

LRFD	ASD
$P_u = (1.2)(200) + (1.6)(300) = 720\ k$	$P_a = 200 + 300 = 500\ k$
$kL = (0.8)(16.5) = 13.2\ ft$	$kL = (0.65)(16.5) = 13.2\ ft$
$\boxed{W12 \times 72}$	$\boxed{W12 \times 72}$

vgcmc

(d)

LRFD	ASD
$P_u = (1.2)(300) + (1.6)(600) = 1320\ k$	$P_a = 300 + 600 = 900\ k$
$kL = (1)(18) = 18\ ft$	$kL = (1)(18) = 18\ ft$
$\boxed{W14 \times 132}$	$\boxed{W14 \times 132}$

vgcmc

PROB #6-8

LRFD	ASD
$P_u = (1.2)(350) + (1.6)(400) = 1060k$	$P_a = 350 + 400 = 750k$
From AISC Table 4-1	From AISC Table 4-1
W10x100 ($\phi_c P_n = 1070k$)	W10x112 ($\frac{P_n}{\Omega_c} = 799k$)
W12x96 ($\phi_c P_n = 1080k$)	W12x106 ($\frac{P_n}{\Omega_c} = 798k$)
→ W14x90 ($\phi_c P_n = 1070k$)	W14x99 ($\frac{P_n}{\Omega_c} = 781k$) ←
$\boxed{\text{USE W14X90}}$	$\boxed{\text{USE W1499}}$

rgcm^c

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PROB #6-9

LRFD	ASD
$P_u = (1.2)(900) + (1.6)(1100) = 2840k$	$P_a = 900 + 1100 = 2000\,k$
Enter Table 4-1 with $K_yL_y = 12ft$ and $F_y = 50ksi$	Enter Table 4-1 with $K_yL_y = 12ft$ and $F_y = 50ksi$
→ W12 x 252 (2910k)	W12x279 (2160k)
W14 X 257 (3110k)	W14x257 (2070k) ←
Try W12X 252 $\left(\frac{r_x}{r_y} = 1.81\right)$	Try W14x257 $\left(\frac{r_x}{r_y} = 1.62\right)$
Equivalent $K_xL_x = \dfrac{K_yL_y}{\frac{r_x}{r_y}} = \dfrac{24}{1.81} = 13.26\ ft$	Equivalent $K_xL_x = \frac{24}{1.62} = 14.8\ ft$
Reenter tables with $K_yL_y = 13.26ft$	Reenter tables with $K_yL_y = 14.8ft$
W12X279 (3132k)	W14X283 (3281k)
or Try W14X257 $\left(\frac{r_x}{r_y} = 1.62\right)$	or Try 12X 279 $\left(\frac{r_x}{r_y} = 1.82\right)$
Equivalent $K_xL_x = \dfrac{24}{1.62} = 14.81\ ft$	Equivalent $K_xL_x = \dfrac{24}{1.82} = 13.19\ ft$
W14X257 (2970k)	W12X279 (2090k)
USE W14X257	USE W12X279

rgcm^c

PROB #6-10

LRFD	ASD
$P_u = (1.2)(350) + (1.6)(400) = 1060k$	$P_a = 350 + 400 = 750k$
Enter AISC Table 4-1 with	Enter AISC Table 4-1 with
$KL_y = 12$ ft	$K_yL_y = 12$ ft
W12×96 (1080k)	W12×106 (798k)
W14×90 (1070k)	W14×99 (751k)
Try W12×96 ($\frac{r_x}{r_y} = 1.76$)	Try W12×106 ($\frac{r_x}{r_y} = 1.76$)
Equivalent $K_xL_x = \dfrac{K_xL_x}{\frac{r_x}{r_y}}$	Equivalent $K_xL_x = \dfrac{K_xL_x}{\frac{r_x}{r_y}}$
$= \frac{24}{1.76} = 13.64$ ft	$= \frac{24}{1.76} = 13.64$ ft
Reenter tables with $K_yL_y = 13.64$ ft	Reenter tables with $K_yL_y = 13.64$ ft
W12×106 (1144k)	W12×106 (762k)
Try lighter W14×90 ($\frac{r_x}{r_y} = 1.66$)	Try lighter W14×99 ($\frac{r_x}{r_y} = 1.66$)
Equivalent $K_xL_x = \dfrac{K_xL_x}{\frac{r_x}{r_y}}$	Equivalent $K_xL_x = \frac{24}{1.66}$
$= \frac{24}{1.66} = 14.46$ ft	$= 14.46$ ft
Reenter tables with $K_yL_y = 14.46$ ft	Reenter tables with $K_yL_y = 14.46$ ft
W14×99 (1116k) ←	W14×109 (819k)
$\boxed{\text{USE W14×99}}$	$\boxed{\text{USE W12×106}}$

✓ gcm

PROB#6-11

LRFD	ASD
$P_u = (1.2)(900) + (1.6)(1100) = 2840\,k$	$P_a = 900 + 1100 = 2000\,ft$
Enter tables with $K_yL_y = 9.33\,ft$	Enter tables with $K_yL_y = 9.33\,ft$
W12X252 ($\phi_c P_n = 3090\,k$)	W12X252 ($\frac{P_n}{\Omega_c} = 2040\,k$)
W14X233 ($\phi_c P_n = 2917\,k$)	W14X257 ($\frac{P_n}{\Omega_c} = 2143\,k$)
Try W12X252 ($\frac{r_x}{r_y} = 1.81$)	Try W12X252 ($\frac{r_x}{r_y} = 1.81$)
Equiv. $K_yL_y = \frac{K_xL_x}{\frac{r_x}{r_y}}$	Equiv. $K_yL_y = \frac{K_xL_x}{\frac{r_x}{r_y}}$
$= \frac{28}{1.81} = 15.47\,ft$	$= \frac{28}{1.81} = 15.47\,ft$
Reenter table with $K_yL_y = 15.47\,ft$	Reenter tables with $K_yL_y = 15.47\,ft$
→ W12X279 ($\phi_c P_n = 2958\,k$)	W12X305 ($\frac{P_n}{\Omega_c} = 2162\,k$)
Try W14X233 ($\frac{r_x}{r_y} = 1.62$)	Try W14X257 ($\frac{r_x}{r_y} = 1.62$)
Equiv $K_yL_y = \frac{K_xL_x}{\frac{r_x}{r_y}}$	Equiv. $K_yL_y = \frac{28}{1.62} = 17.28\,ft$
$= \frac{28}{1.62} = 17.28\,ft$	Reenter Table with $K_yL_y = 17.28\,ft$
Reenter table with $K_yL_y = 17.28$	W14X283 ($\frac{P_n}{\Omega_c} = 2079\,k$) ←
W14X283 ($\phi_c P_n = 3130\,k$)	

ANSWRS. $\boxed{\text{USE W12X279}}$ $\boxed{\text{USE W14X283}}$

r JCMc

PROB # 6-12

LRFD	ASD
$P_u = (1.2)(280) + (1.6)(250) = 736k$	$P_a = 280 + 250 = 530k$
Enter AISC Table 4-1 with $K_yL_y = 10$ ft	Enter AISC Table 4-1 with $K_yL_y = 10$ft
W10X68 ($\phi_c P_n = 768$ k, $\frac{r_x}{r_y} = 1.71$)	W10X77 ($\frac{P_n}{\Omega_c} = 580k$, $\frac{r_x}{r_y} = 1.73$)
W12X65 ($\phi_c P_n = 765k$, $\frac{r_x}{r_y} = 1.75$)	W12X72 ($\frac{P_n}{\Omega_c} = 565k$, $\frac{r_x}{r_y} = 1.75$)
W14X68 ($\phi_c P_n = 755k$, $\frac{r_x}{r_y} = 2.44$)	W14X74 ($\frac{P_n}{\Omega_c} = 549k$, $\frac{r_x}{r_y} = 2.44$)
Try W10X68 (Equivalent $K_yL_y = \frac{20}{1.71} = 11.70$ ft	Try W10X77 (Eq $K_xL_x = \frac{20}{1.73} = 11.56$)
W10X77 ($\phi_c P_n = 823k$)	W10X77 ($\frac{P_n}{\Omega_c} = 550k$)
Try W12X65 (Equivalent $K_yL_y = \frac{20}{1.75} = 11.43$ ft	Try W12X72 (Eq $K_xL_x = \frac{20}{1.75} = 11.43$)
W12X65 ($\phi_c P_n = 738k$)	W12X72 ($\frac{P_n}{\Omega_c} = 545k$)
Try W14X68 (Equivalent $K_yL_y = \frac{20}{2.44} = 8.20$ft, but real $K_yL_y = 10$ft)	Try W14X74 (Eq $K_yL_y = \frac{20}{2.44} = 8.20$ ft) But real $K_yL_y = 10$ft)
→ W14X68 ($\phi_c P_n = 755k$)	W14X74 (549k)
$\boxed{\text{USE W12X65}}$	$\boxed{\text{USE W12X72}}$

√ JCMc

PROB # 6-13

LRFD	ASD
$P_u = (1.2)(150) + (1.6)(350) = 740\,k$	$P_a = 150 + 350 = 500\,k$
Assume $\left(\frac{KL}{r}\right)_x = 40$	Assume $\left(\frac{KL}{r}\right)_x = 40$
$\phi_c F_{cr} = 40$ ksi from AISC Table 4-22	$\frac{F_{cr}}{\Omega_c} = 26.6$ ksi from AISC Table 4-22
A Reqd $= \frac{740}{40} = 18.5\text{ in.}^2$	A Reqd $= \frac{500}{26.6} = 18.8\text{ in.}^2$
Try W14X68 ($A = 20.0\text{ in.}^2$, $r_x = 6.01$ in)	Try W14X68 ($A = 20.0\text{ in.}^2$, $r_x = 6.01$ in)
$\left(\frac{KL}{r}\right)_x = \frac{(1.0)(12)(18)}{6.01} = 35.94$	$\left(\frac{KL}{r}\right)_x = \frac{(1.0)(12)(18)}{6.01} = 35.95$
$\phi_c F_{cr} = 40.92$ ksi	$\frac{F_{cr}}{\Omega_c} = 27.21$ ksi
$\phi_c P_n = (40.92)(20) = 818.4\,k > 740\,k$ OK	$\frac{P_n}{\Omega_c} = (27.21)(20) = 544.2\,k > 500\,k$
Subsequent check of W14X61 shows it will not do	Subsequent check of W14X61 shows it will not do
$\boxed{\text{USE W14X68}}$	$\boxed{\text{USE W14X68}}$

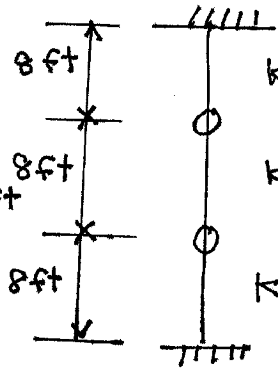
✓ JCM

PROB #6-14

LRFD	ASD
$P_u = (1.2)(225) + (1.6)(450) = 990\,k$	$P_a = 225 + 450 = 675\,k$
Assume $\left(\frac{KL}{r}\right)_x = 30$	Assume $\left(\frac{KL}{r}\right)_x = 30$
$\phi_c F_{cr} = 42.1$ ksi from AISC Table 4-22	$\frac{F_{cr}}{\Omega_c} = 28.0$ ksi
A Reqd $= \frac{990}{42.1} = 23.52$ in.^{2}	A Reqd $= \frac{675}{28.0} = 24.11$ in.^{2}
Try W14x82 ($A = 24.0$ in.^{2}, $r_x = 6.05$ in)	Try W14x90 ($A = 26.5$ in.^{2}, $r_x = 6.14$ in.)
$\left(\frac{KL}{r}\right)_x = \frac{(12)(18)}{6.05} = 35.70$	$\left(\frac{KL}{r}\right)_x = \frac{(12)(18)}{6.14} = 35.18$
$\phi_c F_{cr} = 40.99$ ksi	$\frac{F_{cr}}{\Omega_c} = 27.36$ ksi
$\phi_c P_n = (40.99)(24.0) = 983.8\,k$ N.G.	$\frac{P_n}{\Omega_c} = (27.36)(26.5) = 725\,k > 675\,k$
USE W14X90	USE W14X90

vgLMc

PROB #6-15



$K_xL_x = (0.65)(24) = 15.6\text{ ft}$

$K_yL_y = (0.8)(8) = 6.4\text{ ft}$

$K_yL_y = (1.0)(8) = 8\text{ ft} \leftarrow$

$K_yL_y = (0.8)(8) = 6.4\text{ ft}$

LRFD	ASD
$P_u = (1.2)(400) + (1.6)(275) = 920\text{ k}$	$P_a = 400 + 275 = 675\text{ k}$
Assume $\frac{KL}{r} = 40$	Assume $\frac{KL}{r} = 40$
$\phi_c F_{cr} = 40\text{ ksi}$	$\frac{F_{cr}}{\Omega_c} = 26.6\text{ in.}^2$
$A \text{ Reqd} = \frac{920}{40} = 23\text{ in.}^2$	$A\text{ Reqd} = \frac{675}{26.6} = 25.38\text{ in.}^2$
Try W14X82 ($A = 24.0\text{ in.}^2$, $r_x = 6.05\text{ in}$, $r_y = 2.48\text{ in.}$)	Try W14X90 ($A = 26.5\text{ in.}^2$, $r_x = 6.14\text{ in.}$, $r_y = 3.70\text{ in.}$)
$\left(\frac{KL}{r}\right)_x = \frac{(12)(15.6)}{6.05} = 30.94$	$\left(\frac{KL}{r}\right)_x = \frac{(12)(15.6)}{6.14} = 30.49 \leftarrow$
$\left(\frac{KL}{r}\right)_y = \frac{(12)(8)}{2.48} = 38.71 \leftarrow$	$\left(\frac{KL}{r}\right)_y = \frac{(12)(8)}{3.70} = 25.95$
$\phi_c F_{cr} = 40.36\text{ ksi}$	$\frac{F_{cr}}{\Omega_c} = 27.95\text{ ksi}$
$\phi_c P_n = (40.36)(24.0) = 968.6\text{ k} > 920\text{ k}$	$\frac{P_n}{\Omega_c} = (27.95)(26.5) = 740.7\text{ k} > 675\text{ k}$ ok
$\boxed{\text{USE W14X82}}$	$\boxed{\text{USE W14X90}}$
subsequent check of W14x74 shows it will not do.	Subsequent check of W14X82 shows it will not do.

✓ JCMc

PROB#6-16

(a)

LRFD	ASD
$P_u = (1.2)(100) + (1.6)(150) = 360\,k$	$P_a = 100 + 150 = 250\,k$
$KL = (1.0)(18) = 18\,ft$	$KL = (1.0)(18) = 18\,ft$
W14X61	W14X61
W12X53	W12X53
W10X49	W10X49
W8X67	W8X67
HP12X53	HP12X53
Rect HSS 10X8X$\frac{3}{8}$ (42.7)	Rect HSS 12X10X$\frac{5}{16}$ (44.6)
Square HSS 10X10X$\frac{5}{16}$ (40.3)	Square HSS 10X10X$\frac{5}{16}$ (40.3)
Round HSS 16.000X0.250 (42.1)	Round HSS 16.00X0.250 (42.1)
Pipe 12 Std (49.6)	Pipe 12 STD (49.6)

(b)

LRFD	ASD
$P_u = (1.2)(150) + (1.6)(200) = 500\,k$	$P_a = 150 + 200 = 350\,k$
$KL = (0.65)(16) = 10.4\,ft$	$KL = (0.65)(16) = 10.4\,ft$
W14X53	W14X61
W12X49	W12X49
W10X49	W10X49
W8X58	W8X58
HP10X57	HP10X57
Rect. HSS 12X10X$\frac{3}{8}$ (52.9#)	Rect HSS 12X10X$\frac{3}{8}$ (52.9#)
Square HSS 10X10X$\frac{3}{8}$ (47.8#)	Square HSS 9X9X$\frac{1}{2}$ (55.5#)
Round HSS 16.000X0.312 (52.3#)	Round HSS 16.000X0.312 (52.3#)
Pipe 12XS (65.5#)	Pipe 12 XS (65.5#)

(c)

LRFD	ASD
$P_u = (1.2)(100) + (1.6)(600) = 1080\,k$	$P_a = 100 + 600 = 700\,k$
$KL = (0.8)(20) = 16\,ft$	$KL = (0.8)(20) = 16\,ft$
W14X99	W14X99
W12X120	W12X106
HP14X102	HP14X102
Rect HSS 20X12X$\frac{5}{8}$ (127)	Rect HSS 20X12X$\frac{5}{8}$ (127)
Square HSS 16X16X$\frac{1}{2}$ (103)	Square HSS 16X16X$\frac{1}{2}$ (103)
Round HSS none	Round HSS none
Pipe none	Pipe none

JCMc

PROB # 6-17

ESTIMATION OF LOADS

Roof

Roof slab $= \left(\frac{4}{12}\right)(150)(40)(36) = 72{,}000$ lbs
Roofing $= (6)(40)(36) = 8{,}640$
Est. col. wt. + firepfing. $= 500$
$P_D = 81{,}140$ lbs

$P_L = (30)(40)(36) = 43{,}200$ lbs

$P_u = (1.2)(81.14) + (1.6)(43.2) = 166.5$ k
$KL = 12$ ft

W14X43

THIRD FLOOR

Floor slab $= \left(\frac{6}{12}\right)(150)(40)(36) = 108{,}000$ lbs
Est col wt + firepfg. $= 500$
$P_D = 108{,}500$ lbs

Partitions $(15)(40)(36) = 21{,}600$
Live Load $= (80)(40)(36) = 115{,}200$
$P_L = 136{,}800$

Total Load $= (1.2)(108.5) + (1.6)(136.8)$
$+ 166.5$ from above $= 515.58$ k
$KL = 12$ ft

W14X61

JLMc

PROB # 6-17 CONTD.

SECOND FLOOR

Total Load = (1.2)(108.5) + (1.6)(136.8) + 515.58 from above

= 864.66 k

KL = 12 ft

W14 X 90

FIRST FLOOR

Total Load = (1.2)(108.5) + (1.6)(136.8) + 864.66 from above

= 1213.74 k

KL = 12 ft

W14 X 109

USE W14 X 61 TOP TWO FLOORS
AND W 14 X 109 BOTTOM TWO FLOORS

vg cmc

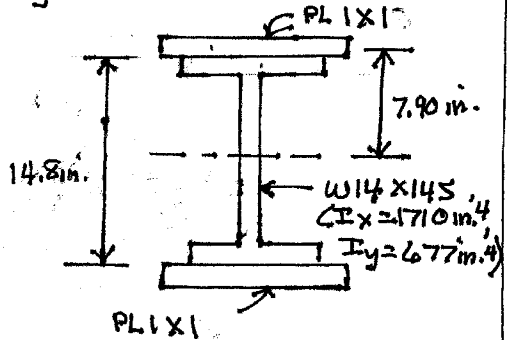
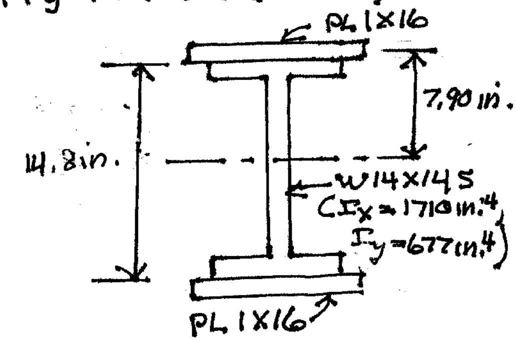
PROB # 6-18

LRFD	ASD
$P_u = (1.2)(800) + (1.6)(1200) = 2880\,k$	$P_a = 800 + 1200 = 2000\,k$

Assume $\frac{KL}{r} = 35$

LRFD	ASD
$\phi_c F_{cr} = 41.2\text{ in.}^2$ $A\text{ Reqd} = \frac{2880}{41.2} = 69.90\text{ in.}^2$	$\frac{F_{cr}}{\Omega_c} = 27.4\text{ in.}^2$ $A\text{ Reqd} = \frac{2000}{27.4} = 72.99\text{ in.}^2$

Try W14X145 ($A = 42.7\text{ in.}^2$, $d = 14.8$ in., $b_f = 15.50$ in., $I_x = 1710\text{ in.}^4$, $I_y = 677\text{ in.}^4$)

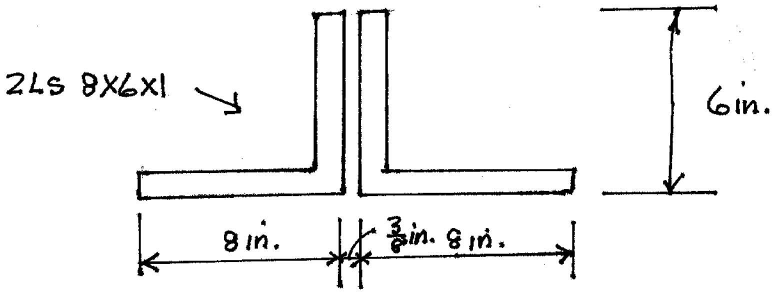
LRFD	ASD
Est. area of plates $= 69.90 - 42.7 = 27.2\text{ in.}^2$ Try 1 PL 1X14 (14.00 in.^2) each fl.	Est. area of plates $= 72.99 - 42.7 = 30.29\text{ in.}^2$ Try 1 PL 1X16 (16.00 in.^2) each fl.
 	
$A = 42.7 + (2)(14) = 70.7\text{ in.}^2$ $I_x = 1710 + (2)(14)(7.90)^2 = 3457\text{ in.}^4$ $I_y = 677 + (2)(\frac{1}{12})(1)(14)^3 = 1134\text{ in.}^4$ $r_y = \sqrt{\frac{1134}{70.7}} = 4.00\text{ in.}$ $\left(\frac{KL}{r}\right)_y = \frac{(12)(12)}{4.00} = 36$	$A = 42.7 + (2)(16) = 74.7\text{ in.}^2$ $I_x = 1710 + (2)(16)(7.90)^2 = 3707\text{ in.}^4$ $I_y = 677 + (2)(\frac{1}{12})(1)(16)^3 = 1360\text{ in.}^4$ $r_y = \sqrt{\frac{1360}{74.7}} = 4.27\text{ in.}$ $\left(\frac{KL}{r}\right)_y = \frac{(12)(12)}{4.27} = 33.72$

PROB # 6-18 CONTD.

LRFD	ASD
From AISC Table 4-22	From AISC Table 4-22
$\phi_c F_{cr} = 40.9\ ksi$	$\frac{F_{cr}}{\Omega_c} = 27.56\ ksi$
$\phi_c P_n = (40.9)(70.7)$	$\frac{P_n}{\Omega_c} = (27.56)(74.7)$
$= 2891k > 2880k$	$= 2059k > 2000k$ ok
$\boxed{\text{USE W14X145 WITH 1 PL 1X14 EACH FLANGE}}$	$\boxed{\text{USE W14X145 WITH 1 PL 1X16 EA FLANGE}}$

vgcm

PROB #6-19



Using 2LS 8X6X1 (For each angle $A = 13.0\ in.^2$, $I_x = 38.8\ in.^4$, $I_y = 80.9\ in.^4$)

$$I_x = (2)(38.8) = 77.6\ in.^4$$

$$I_y = (2)\left[80.9 + (13.0)\left(2.65 + \frac{0.375}{2}\right)^2\right] = 371.1\ in.^4$$

$$r_x = \sqrt{\frac{77.6}{(2)(13.0)}} = 1.73\ in.$$

$$r_y = \sqrt{\frac{371.1}{(2)(13.0)}} = 4.02\ in.$$

$$\left(\frac{KL}{r}\right)_x = \frac{(12)(20)}{1.73} = 138.73 \Leftarrow$$

$$\left(\frac{KL}{r}\right)_y = \frac{12 \times 20}{4.02} = 59.70$$

Referring to AISC Section E6.1

a = distance between connectors $= (4)(12) = 48\ in.$

$r_i = r_z$ for 1 angle $= 1.28\ in.$

$$\frac{Ka}{r_i} = \frac{(1.0)(48)}{1.28} = 37.5 < \frac{3}{4} \times 138.73 = 104 \text{ ok}$$

As $\left(\frac{KL}{r}\right)_x$ controls the buckling mode does not involve relative deformations that produce shear forces in the connectors between the two angles.

LRFD	ASD
$\phi_c F_{cr} = 11.75\ ksi$ $\phi_c P_n = (11.75)(2 \times 13.0) = \boxed{305.5\ k}$	$\frac{F_{cr}}{\Omega_c} = 7.67\ ksi$ $\frac{P_n}{\Omega_c} = (7.67)(2 \times 13.0) = \boxed{199.4\ k}$

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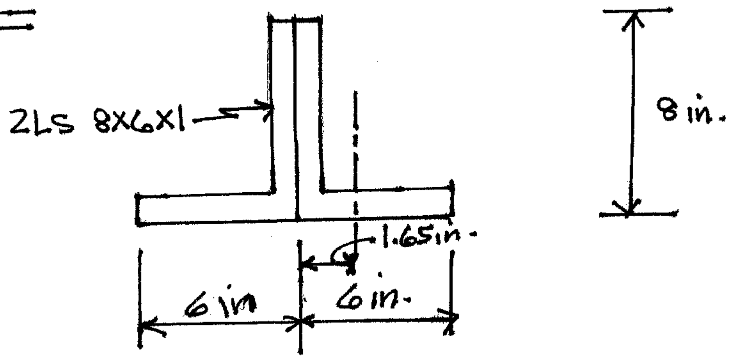
PROB#6-20



Using 2 Ls 8X6X1 LLBB (For each angle $A = 13.0\,in.^2$, $I_x = 80.9\,in.^4$, $I_y = 38.8\,in.^4$, $r_y = 1.72\,in.$, $r_z = 1.28\,in.$)

$I_x = (2)(80.9) = 161.8\,in.^4$

$I_y = 2[38.8 + (13.0)(1.65)^2] = 148.4\,in.^4$

$r_x = \sqrt{\dfrac{161.8}{(2)(13.0)}} = 2.49\,in.$

$r_y = \sqrt{\dfrac{148.4}{(2)(13.0)}} = 2.39\,in.$

$\left(\dfrac{KL}{r}\right)_x = \dfrac{(12)(20)}{2.49} = 96.39$

$\left(\dfrac{KL}{r}\right)_y = \dfrac{(12)(20)}{2.39} = 100.42 \Leftarrow$

Referring to Section E6.1 of the AISC Spec.

a = distance between welds $= 6 \times 12 = 72\,in.$

$r_i = r_z$ for 1 angle $= 1.28\,in.$

$\dfrac{Ka}{r_i} = \dfrac{72}{1.28} = 56.25 < \frac{3}{4} \times 100.42 = 75.31$ ok

As $\left(\frac{KL}{r}\right)_y$ controls, the buckling mode does involve relative deformations that produce shear forces in the welds between the two angles.

(signature)

PROB #6-20 CONTD.

$$\left(\frac{KL}{r}\right)_m = \sqrt{\left(\frac{KL}{r}\right)_o^2 + 0.82\frac{\alpha^2}{(1+\alpha^2)}\left(\frac{a}{r_{ib}}\right)^2} \quad \text{(AISC Eq. E6-2)}$$

$r_{ib} = 1.72$ in.

$$\alpha = \frac{h}{2r_{ib}} = \frac{(2)(1.65)}{(2)(1.72)} = 0.959$$

$$\left(\frac{KL}{r}\right)_m = \sqrt{(100.42)^2 + (0.82)\frac{0.959^2}{(1+0.959^2)}\left(\frac{72}{1.72}\right)^2}$$

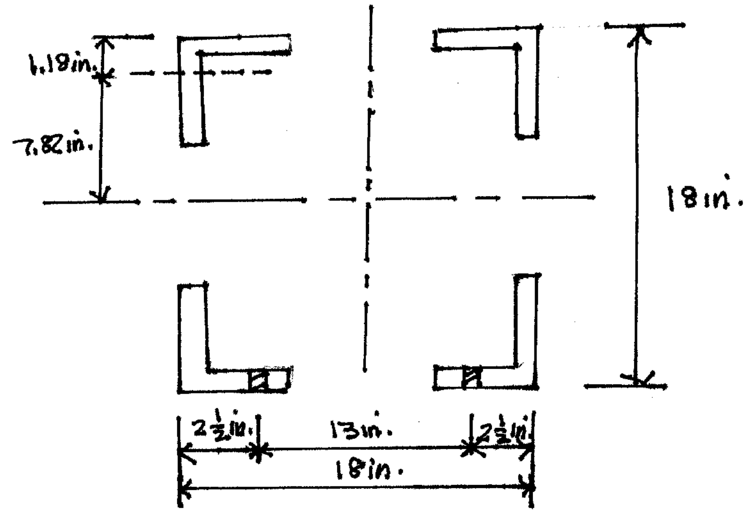
$$= 103.78$$

LRFD	ASD
$\phi_c F_{cr} = 18.34$ ksi $\phi_c P_n = (18.34)(2 \times 13.0)$ $= 476.8$ k	$\frac{F_{cr}}{\Omega_c} = 12.22$ ksi $\frac{P_n}{\Omega_c} = (12.22)(2 \times 13.0) = 317.7$ k

✓ JCME

PROB # 6-21

Using 4 Ls 4x4x $\frac{1}{2}$ ($A = 3.75\ in^2$ each, $I_x = I_y = 5.52\ in^4$ each)



$I_x = I_y = 4\,[5.52 + (3.75)(7.82)^2] = 939.4\ in^4$

$r_x = r_y = \sqrt{\frac{939.4}{(4)(3.75)}} = 7.91\ in.$

$\left(\frac{KL}{r}\right)_x = \left(\frac{KL}{r}\right)_y = \frac{(12)(30)}{7.91} = 45.51$

LRFD	ASD
$\phi_c F_{cr} = 29.049$ ksi $\phi_c P_n = (29.049)(4 \times 3.75) = \boxed{435.7k}$	$\frac{F_{cr}}{\Omega_c} = 19.349$ ksi $\frac{P_n}{\Omega_c} = (19.349)(4 \times 3.75) = \boxed{290.2k}$

Design of End Tie PLs

Min. length = 13 in.

Min. width = $13 + (2)(1\frac{1}{4}) = 15.5$ in.

Min. $t = \left(\frac{1}{50}\right)(13) = 0.26$ in.

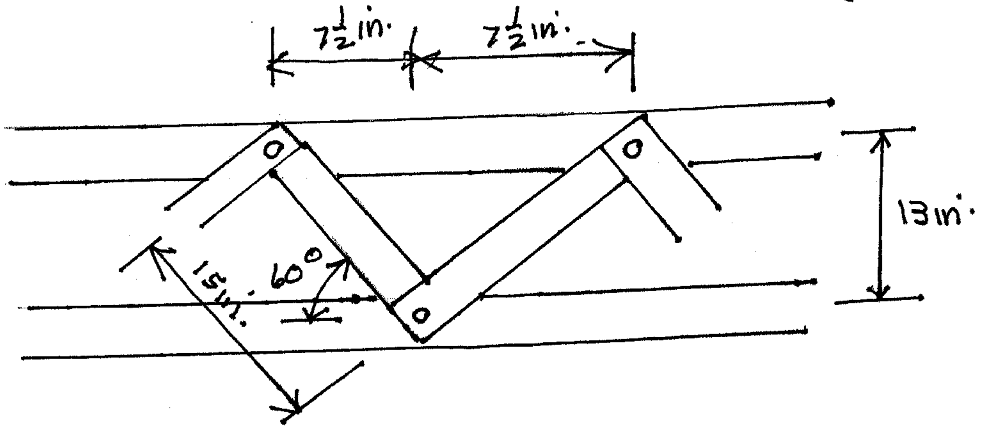
$\boxed{\text{USE END TIE PLs } \frac{9}{32} \times 13 \times 1 \text{ ft-4 in.}}$

PROB#6-21 CONTD.

Design of single lacing (LRFD)

Assume lacing inclined @ 60° with main members

Shear = (0.02)(435.7) = 8.71 k or 4.36 k/lacing bar



Member length $= \frac{13}{\cos 30^\circ} + (2)(1\frac{1}{4}) = 17\frac{1}{2}$ in.

Resultant member force $= \left(\frac{15}{13}\right)(4.36) = 5.03$ k compress.

Assume $\frac{L}{r} = 140$

$\frac{15}{0.289t} = 140$

$t = 0.370$ in. Say $\frac{3}{8}$ in.

$\frac{L}{r} = \frac{15}{(0.289)(3/8)} = 138.4$

$\phi_c F_{cr} = 11.82$ ksi

A Reqd $= \frac{5.03}{11.82} = 0.426$ in.^{2}

Width reqd $= \frac{0.426}{3/8} = 1.14$ in.

But min. width $= (2)(1\frac{1}{4}) = 2\frac{1}{2}$ in.

$\boxed{\text{USE LACING BARS } \frac{3}{8} \times 2\frac{1}{2} \times 1\text{ ft } 5\frac{1}{2}\text{ in. (LRFD)}}$

✓ J.C.McC

PROB # 6-22

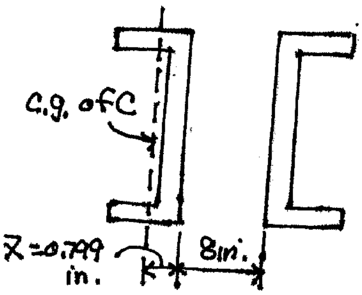
LRFD	ASD
$P_u = (1.2)(200) + (1.6)(440) = 944$ k	$P_a = 200 + 440 = 640$ k

Assume $\frac{KL}{r} = 50$

$\phi_c F_{cr} = 37.50$ ksi (AISC Table 4-22)

A Reqd = $\frac{944}{37.50} = 25.17$ in.^{2} or 12.59 in.^{2} per C

Try 2Cs 15x50 [For each channel $A = 14.7$ in.^{2}, $\bar{x} = 0.799$ in., $I_x = 404$ in.^{4}, $I_y = 11.0$ in.^{4}, $r_y = 0.865$ in.)



$I_x = (2)(404) = 808$ in.^{4}

$I_y = (2)(11) + (2)(14.7)(4.799)^2 = 699.1$ in.^{4}

$r_y = \sqrt{\frac{699.1}{(2)(14.7)}} = 4.88$ in.

$\left(\frac{KL}{r}\right)_y = \frac{(1)(12 \times 24)}{4.88} = 59.02$

LRFD	ASD
$\phi_c F_{cr} = 34.89$ ksi $\phi_c P_n = (34.89)(2 \times 14.7) = 1025.8$ k > 944 k	$\frac{F_{cr}}{\Omega_c} = 23.20$ ksi $\frac{P_n}{\Omega_c} = (23.20)(2 \times 14.7) = 682.8 > 640$ k

PROB# 6-22 CONT'D.

Design of End Tie Plates

Bolt line is located $2\frac{1}{4}$ in. from back of Cs

Distance between bolt lines $= 8 + (2)(2\frac{1}{4}) = 12.5$ in.

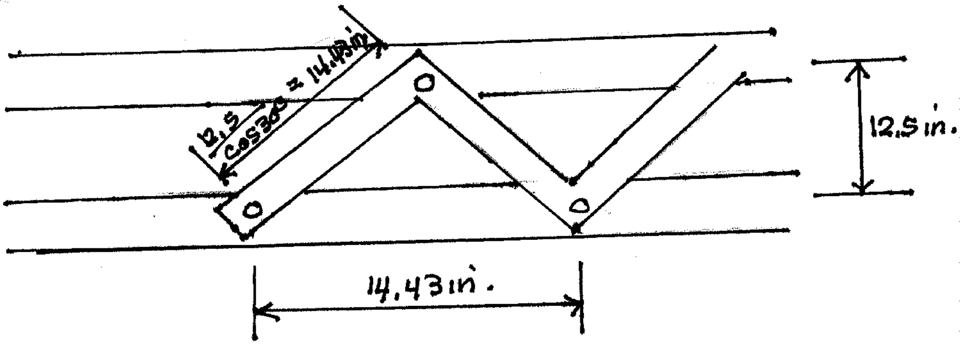
Min. length of plates $= 12.5$ in.

Min. width $= 12.5 + (2)(1\frac{1}{4}) = 15$ in.

Min. $t = \left(\frac{1}{50}\right)(12.5) = 0.25$ in.

USE END TIE PLs $\frac{1}{4} \times 12\frac{1}{2} \times 1$ ft 3 in.

Design of Single Lacing



$\frac{L}{r}$ of C between lacing $= \frac{14.43}{0.865} = 16.68 < 59.02$ ok

Shear to be taken by lacing $= (0.02)(944) = 18.88$ or 9.44 ea side

Max compression force $= \frac{9.44}{\cos 30^\circ} = 10.90$ k

Length of lacing bars $= 14.43 + (2)(1\frac{1}{4}) = 16.93$ Say 17 in.

Assume $\frac{L}{r} = 140$

$$\frac{14.43}{0.289t} = 140$$

$t = 0.357$ in. Say $\frac{3}{8}$ in.

$$\frac{KL}{r} = \frac{(1)(14.43)}{(0.289)(0.375)} = 133.15$$

$\phi_c F_{cr} = 12.77$ ksi

A Reqd $= \frac{10.90}{12.77} = 0.854$ in.^{2}

width reqd $= \frac{0.854}{0.375} = 2.28$ in.

say $(2)(1\frac{1}{4}) = 2\frac{1}{2}$ in. to provide suff. edge dist.

USE LACING $\frac{3}{8} \times 2\frac{1}{2} \times 1$ ft 5 in.